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MICROCOMPUTER BASED INTEGRATED TRAFFIC SYSTEM

MARKET STUDY AND CONCEPTUAL DESIGN

FINAL REPORT

Prepared for
Transportation Development Centre

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NOVEMBER 1985

IBI GROUP

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MICROCOMPUTER BASED INTEGRATED TRAFFIC STUDY

MARKET STUDY AND CONCEPTUAL DESIGN
FINAL REPORT

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IBI GROUP
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17. Abstract

There have been considerable developments in microcomputers as well as traffic engineering application software. The full potential of the software has not been achieved because of data handling requirements, which can be a major factor in analysis programs.

The purpose of this study was to assess the market for and requirements of an integrated traffic analysis system. The study concluded that an Integrated Traffic System (ITS) can offer significant benefits: reduced energy consumption, delay and congestion, and improved safety and staff utilization. The main functions of ITS would be accident analysis, traffic operations and inventory systems. The resulting ITS should be non-proprietary and designed to adapt to and evolve with new hardware and new application software. The report recommends that a demonstration of the system be undertaken in selected cities.

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17. Résumé

Ce rapport rend compte des progrès réalisés dans l'application de la micro-électronique au développement des techniques de régulation du trafic urbain, qui restent cependant en-deçà de leur potentiel en raison des difficultés dans la saisie des données, facteur important de tout programme d'analyse.

Il décrit la recherche qui a été faite pour étudier les caractéristiques d'un système intégré d'analyse du trafic et sa part du marché. L'étude a montré les avantages d'un tel système: réduction de la consommation, des temps d'attente et des encombrements aux carrefours, ainsi que sécurité accrue et meilleure productivité du personnel. Les tâches à être confiées à ce système seraient l'analyse des accidents, la gestion du trafic et la collecte de données statistiques. Le rapport préconise que le système, dont la propriété serait publique, ait un caractère évolutif, s'adaptant aux progrès réalisés tant dans les matériels que dans les logiciels d'application. Il ajoute que ce système devrait être mis en service expérimental dans certaines villes sélectionnées.

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EXECUTIVE SUMMARY

Improved traffic control, such as optimized signal timing and the elimination of stop signs, offers the potential to save some 2% to 3% of the urban transportation energy consumption, approximately 400,000,000 litres in Canada annually. The full potential of these benefits, however, has not been achieved because of limitations associated with the time and resources for staff to undertake the necessary analysis. With the considerable developments in microcomputers as well as traffic engineering application software, a microcomputer based traffic analysis system offers an effective and efficient approach to automating the time-consuming tasks of traffic engineering, thus enabling traffic improvements to be implemented in a more timely manner.

The purpose of the study was to assess the potential benefits of, and market for, an Integrated Traffic System (ITS). The ITS would be designed to run on a microcomputer and would provide a means for consistent handling of data input and output for a selection of traffic operations/analysis programs. ITS was thought to have significant potential because:

- microcomputers which have been evolving at a very rapid pace, have become price competitive and are in widespread use;
- a number of microcomputer traffic analysis programs have been developed for specific purposes or have been adapted from mainframe environments;
- the lack of resources required to collect and analyze traffic data has traditionally been a deterrent in achieving the potential benefits associated with proper traffic engineering;
- the majority of application programs that have been developed to date are stand-alone programs that lack data base integration.

The major activities performed in the study include:

- a survey of existing hardware and software suppliers. The traffic engineering hardware systems were reviewed under the categories: on-site data collection, centralized data collection and traffic control systems while the traffic engineering software was classified into single-function and multi-function applications.

- a survey of traffic engineering agencies to determine their needs. The survey was directed at traffic engineering practitioners at the municipal and provincial level with representatives selected from across Canada.

- an assessment of the requirements associated with the development of an Integrated Traffic System. It was apparent that there is a need for a multi-functional system which integrates programs from three functional groups: accident analysis and reporting, traffic operations and infrastructure inventories. Additional requirements included external interfaces to data collection subsystems, commercial software packages and a signal monitoring subsystem.

- the development of a prototype Integrated Traffic System. The prototype was developed using a relational data base management system (DBMS) which provides the core for interfacing various input and output facilities to form a complete and comprehensive system to support the traffic engineer.

- an assessment of the potential benefits. These benefits were quantified under the categories: travel benefits such as energy consumption and reduced vehicle delay, increased safety and information processing efficiency.

The study concludes that a microcomputer based Integrated Traffic System is justified as there are significant benefits, including reduced energy consumption, reduced delay and congestion, improved safety and improved staff utilization. The basic functions required in an ITS system were identified as traffic analysis tabulating and reporting, traffic operations analysis and equipment inventories. It was also concluded that ITS should be non-proprietary and designed to adapt and evolve with new hardware and new application software. The study recommends that a development and demonstration phase be undertaken in selected cities.

RÉSUMÉ A L'INTENTION DE LA DIRECTION

Une meilleure gestion de la circulation, par exemple grâce à une synchronisation optimalisée de la signalisation et à l'élimination de panneaux d'arrêt, laisse entrevoir la possibilité de réduire de 2 à 3 % la consommation d'énergie en transport urbain, soit environ 400 000 000 litres de carburant chaque année au Canada. Cependant, on n'a pu établir le bilan complet de ces avantages éventuels faute du temps et des ressources nécessaires pour que le personnel procède à l'analyse voulue. Étant donné les progrès considérables qu'ont connus les micro-ordinateurs, de même que le logiciel appliqué à la gestion de la circulation, un système d'analyse de cette circulation piloté par micro-ordinateur constitue un outil efficace pour automatiser les tâches exigeantes de cette gestion au point de vue temps et donc d'instaurer des améliorations en temps plus utile.

L'étude visait d'abord à évaluer les avantages éventuels et le marché d'un système de gestion intégrée de la circulation (ITS). Un tel système serait conçu en fonction d'un micro-ordinateur et pourrait traiter de façon cohérente les données d'entrée et de sortie ayant trait à un choix d'opérations ou de programmes d'analyse en matière de circulation. On a estimé que le système ITS offrait beaucoup de possibilités dans ce domaine pour les raisons suivantes:

- les micro-ordinateurs ayant connu une évolution très rapide, ils sont maintenant d'un prix abordable et leur usage est largement répandu;
- un certain nombre de programmes d'étude de la circulation par micro-ordinateur ont été élaborés à des fins particulières ou ont été adaptés étant donné qu'ils étaient utilisés avec un ordinateur central;
- faute des ressources nécessaires pour recueillir et analyser les données de la circulation, on n'a jamais pu bénéficier de tous les avantages pouvant découler d'une bonne gestion de la circulation; et

- la plupart des programmes d'application qui ont été mis au point jusqu'à maintenant sont autonomes et ne comportent pas une intégration de leur base de données.

Voici les principales activités aux quelles l'étude a donné lieu:

- l'examen des fournisseurs existants de matériel et de logiciel. Les systèmes matériels dans le domaine ont été examinés selon les catégories suivantes: collecte des données sur le terrain ou de façon centralisée de même que gestion de la circulation; alors que le logiciel, lui, a été réparti en applications à fonction unique et multifonction;

- une enquête auprès des agences en gestion de la circulation pour connaître leurs besoins. On s'est adressé aux praticiens de la circulation aux niveaux municipal et provincial, en particulier à des représentants choisis à travers le Canada;

- une évaluation des besoins qu'engendre l'élaboration d'un Système de gestion intégrée de la circulation. Il est ressorti clairement la nécessité d'un système multifonction qui recouvre les programmes provenant de trois groupes fonctionnels: compte rendu et analyse des accidents, opérations relatives à la circulation et inventaire de l'infrastucture. Ont également été jugés indispensables: des interfaces externes avec les sous-systèmes de collecte des données, des progiciels disponibles sur le marché et un sous-système de surveillance de la signalisation;

- la mise au point d'un prototype d'un Système de gestion intégrée de la circulation. Le prototype a été élaboré à partir d'un système de gestion de base de données relationnelles (SGBDR); ce noyau permet l'interface de divers dispositifs d'entrée et de sortie de manière à constituer un système complet et approfondi venant appuyer le travail du technicien en circulation; et

- une èvaluation des avantages éventuels. Ceux-ci ont été quantifiés selon les catégories suivantes: avantages ayant trait aux déplacements comme l'économie d'énergie et un déplacement plus rapide des véhicules, un accroissement de la sécurité et l'efficacité de l'informatique.

L'étude conclue qu'un Système de gestion intégrée de la circulation, piloté par micro-ordinateur, se justifie par des avantages considérables, notamment une réduction de la consommation énergétique, une diminution des retards et des ralentissements, un accroissement de la sécurité et une meilleure utilisation du personnel. On a estimé que les fonctions de base nécessaires à un tel système sont la mise en tableaux et le compte rendu de l'analyse de la circulation, l'étude des opérations ayant trait à la circulation et l'inventaire de l'équipement. On est également parvenu à la conclusion que le système ITS ne devait pas être un logiciel maison et qu'il devait être conçu de manière à s'adapter et à évoluer en même temps que le nouveau matériel et le logiciel d'application. Enfin, l'étude recommande qu'une étape de développement et de démonstration soit entreprise dans certaines villes.

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APPENDICES

A - Summary of Hardware and Software Products/Suppliers

B - Microcomputer Traffic Analysis Survey Questionnaire

C - Preliminary Review of Typical Traffic Analysis Programs

1.0 INTRODUCTION

Improved traffic control, such as improved traffic signal timing and the elimination of stop signs, etc., offers the potential to save some 2% to 3% of the urban transportation energy consumption; approximately 400,000,000 litres in Canada annually. One of the limitations in achieving these ultimate benefits is associated with the time and resources for staff to undertake the necessary analysis. A microcomputer based traffic analysis system would reduce the manpower and resource requirements enabling traffic improvements to be implemented in a more timely manner.

IBI Group responded to this identified need and submitted a proposal in response to the DSS general call for proposals on energy R & D projects in March 1983.

This report summarizes the findings of the study which was undertaken for the Transportation Development Centre of Transport Canada. The purpose of the study was:

- o assess the potential benefits and market for an Integrated Traffic System;

There are a number of points worthy of comment that provide an important context to the study:

- o microcomputers have been evolving at a very rapid pace. They have become price competitive and are in widespread use.

- a number of traffic analysis programs have been adapted from mainframe environments to microcomputers or have been developed by traffic engineers for specific purposes;
- one of the major shortcomings in achieving the potential energy, safety and other benefits associated with proper traffic engineering has been the lack of resources required to collect and analyze the data;
- one of the major shortcomings in achieving the potential energy, safety and other benefits associated with proper traffic engineering has been the lack of resources required to collect and analyze the data;
- one of the major difficulties in using various application programs that have been developed is that they are stand-alone programs that lack data base integration. Moreover, the major hurdle in using many of these programs is simply the data entry and manipulation.

Based on the above, this study was undertaken. The major activities included in the study were:

- survey of existing hardware and software suppliers;
- survey of users to determine needs;
- an assessment of the requirements associated with the development job of an Integrated Traffic System;
- an estimate of the potential benefits.

The following chapters are structured in the above fashion addressing each of these major points.

To assist in the overall project, a Steering Committee was formed to provide input and advice throughout the course of the project. The composition of the Steering Committee is summarized in Exhibit 1.1.

EXHIBIT 1.1

STEERING COMMITTEE MEMBERS

L. Suen (Chair)	Transportation Development Centre
M. Harmelink	Ontario Ministry of Transportation and Communications
G. Heti	Ontario Ministry of Transportation and Communications
L. Holowachuk	B. C. Ministry of Transportation and Highways
R. Walshaw	City of Calgary
M. Hirt	City of Winnipeg
J. Hindson	City of Hamilton
R. Vezina	City of Montreal
C. Foster	Regional Municipality of Niagara
M. Sheflin	Regional Municipality of Ottawa-Carleton
W. Olscher	Regional Municipality of Ottawa-Carleton
T. Mainland	Regional Municiaplity of Waterloo
B. Allen	McMaster University

Consultants

S. Stewart	IBI Group
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M. Quinn	IBI Group
K. Jang	IBI Group

2.0 SURVEY OF HARDWARE AND SOFTWARE PRODUCTS/SUPPLIERS

2.1 INTRODUCTION

There have been a number of hardware and software developments to date for traffic analysis. Many of these systems however are only available on mainframe computers and are not generally available nor suitable to smaller municipalities while others that are operational on a microcomputer are limited in capabilities and are specific to certain types of hardware. In order to assess the market suitability for a microcomputer-based traffic analysis system, the current microcomputer technology including hardware and software was reviewed.

Within this survey, traffic engineering hardware systems were classified into three categories:

- o on-site data collection systems;
- o centralized data collection systems;
- o traffic control systems.

The hardware products reviewed in this survey represent a cross section of the existing hardware which can be integrated into a microcomputer based system.

Traffic Engineering software was classified into single-function applications and multi-functions applications. The evaluated software systems include products developed under different operating systems and

developed for a wide range of microcomputers. This study is not concerned with limitations with regards to microcomputer or operating system type as software products can be modified or adapted to new environments as required. Sources for software analysis packages included government agencies (e.g. FHWA), user groups (e.g. STEAM), professional associations (e.g. ITE) and software consultants.

Appendix A presents a summary of hardware and software products/suppliers along with a review of their functionality with regards to traffic engineering applications.

2.2 EXISTING TRAFFIC ANALYSIS SYSTEMS - HARDWARE

2.2.1 On-Site Data Collection Systems

The data collection systems reviewed in this study are commercially available to the traffic engineering community. These systems are generally portable in nature and have the capability to output data directly into a microcomputer (i.e. automatic entry of data through RS232 standard interface). On-site data collection systems include:

- o intersection counters;
- o volume counters;
- o traffic classifiers.

A detailed review of representative hardware with respect to operating features, availability, cost and proprietary nature is summarized below.

The Timelapse TMC/48 is one example of an electronic device for manual intersection counting. The TMC/48 records turning movement counts for up to 12 lanes distributed over four approaches. The count data is

recorded at distinct time intervals with automatic interval updates. This device provides the capability for recording pedestrian and/or bicycle counts; however, it does not permit the user to record special vehicles such as trucks and buses. Upon power up, a system diagnostics program for simple checking of memory, switches and display is activated. The DATADUMP package allows one to transfer the count data directly from the system memory to a microcomputer. In addition, the TMC analysis software package written in BASIC allows one to print out the results of a count automatically. The TMC/48 retails for approximately $2,000 (with software) and $2,400 (with software and expansion assistant unit).

Volume counters and speed classifiers distributed by Timelapse include the GK Instruments series. These counting units which utilize solid state removal RAM memory can be interfaced to two road tubes and up to six detector loops. A built-in RS232 interface unit is available for direct connection to a printer or microcomputer. Various software utilities have been included for the generation of simple reports, editing and permanent storage on disk. These traffic counters and speed classifiers are priced in the range of $1,600 to $3,200.

The Golden River Marksman series of traffic counters, classifiers and retrievers represent a family of compatible data collection hardware. The hardware can be interfaced with up to two road tubes and six detector loops and also permits the transfer of data through an RS232 port. An optional TRANSPAC software package provides comprehensive editing, inquiry and report preparation facilities. These units are individually priced as follows: counters ($2,000 U.S.), classifiers ($3,000 U.S.), retrievers ($2,900 U.S.) and software ($4,000 U.S.).

The PEER 2000 Portable Event Recorder developed by the Computer Technology Group combines both the functions of intersection counting and volume and speed classification. This unit may be employed both as a manual input intersection counter and a permanent count station retriever

as it accepts input from loop detectors and road tubes. In addition, optional PEERSOFT programs, memory expansion modules and auxiliary slave units are available for increased functionality. The base unit is priced at approximately $2,200.

Exhibit 2.1 summarizes the main aspects of each on-site data collection system.

2.2.2 Centralized Data Collection Systems

Centralized data collection systems consist of hardware which allows one to retrieve traffic counts and/or speed classification data from remote sites. Typical hardware layout at the central office may include a microcomputer, modem and telephone lines. Entry of site identification codes, valid telephone numbers and set up parameters allows one to poll a counter/classifier over a normal telephone line. In many systems, automatic polling using built-in clocks can be activated. Data is often retrieved overnight and stored on disk for future analysis.

Two examples of centralized data collection systems include the TELMET system developed by Golden River Highway and Traffic Data Systems and the TELAC system developed by Mangood Limited. Both systems utilize a fully automatic telemetry system which polls up to 200 remote locations over the telephone line. In addition, the two systems offer optional software which run on the IBM PC for subsequent analysis.

2.2.3 Traffic Control Systems

A review of traffic control hardware systems has been included in this study for the sake of "completeness". It is not anticipated that the current microcomputer technology can provide sufficient processing capability for area-wide traffic control as presently applied. However, with the increasing speeds and capabilities of the microcomputer, it may be quite feasible to develop an integrated package for both analysis and limited control.

EXHIBIT 2.1

TRAFFIC DATA COLLECTION SYSTEMS

SUPPLIER/PRODUCT	OPERATIONAL CHARACTERISTICS	ACCESSORIES/OPTIONS	COSTS
TIMELAPSE TMC/48	- intersection counter - turning movement counts by 5 or 15 minutes - solid state memory with RS232 interface	- TMC Analysis software - TMC Assistant	$2,000 (with software) $2,400 (with software and assistant)
G.K. INSTRUMENTS LTD.	- volume counts and speed classifications - portable units or permanent stations (telemetry system) - 2 road tubes and/or 6 detector loops - RS232 interface	- software for reports and plots	portable recorder $2,500 permanent station $1,600 - $3,200
GOLDEN RIVER MARKSMAN	- traffic counter, classifiers and retrievers - 2 road tubes and 6 loops - RS232 interface	- Transpac software	counters $2,000 U.S. classifiers $3,000 U.S. retriever $2,900 U.S. software $4,000 U.S.
COMPUTER TECHNOLOGY GROUP PEER 2000	- turning movement and pedestrian counts - printer interface for reports - RS232 interface - accepts inputs from loop detectors on road tubes	- PEERMASTER Data System - PEERSOFT - memory expansion module - auxiliary slave	$2,200

Three representative hardware systems for area-wide traffic control include:

1. VMS220 (Multisonics).
2. KMC-10000 (Econolite Control Products).
3. HMP290 (Traconex Incorporated).

Within a functional context, all three systems are similar in nature. These three units provide the capability for monitoring and controlling intersections as their integrated hardware and software components create a dedicated system for traffic control. The VMS220 and HMP290 were designed for centralized control while the KMC-10000 utilizes an IBM PC as its central processor which relays information to a number of "intelligent" intersection controllers.

2.2.4 Hardware Evaluation

Exhibit 2.2 presents a bar chart which identifies the functionality of the surveyed hardware products by traffic engineering application. The primary, secondary and/or related functions for each product were initially identified and then cumulatively totalled to reflect the current functionality trend. Hardware systems are generally limited to the tasks of data collection, traffic signal operations, volume count summaries and data file transfers.

The attribute of hardware versatility with respect to traffic engineering applications is presented in Exhibit 2.3. This histogram identifies the % of products surveyed by the number of equivalent primary functions (EPF). The EPF value is identified by employing weighting factors of 0.5 and 0.33 for the secondary functions and related functions, respectively. The EPF value is then calculated by multiplying the number of functions in each category (i.e. primary, secondary and related) by the appropriate factor and then totalling the results across the categories.

EXHIBIT 2.2

SUMMARY OF HARDWARE FUNCTIONALITY

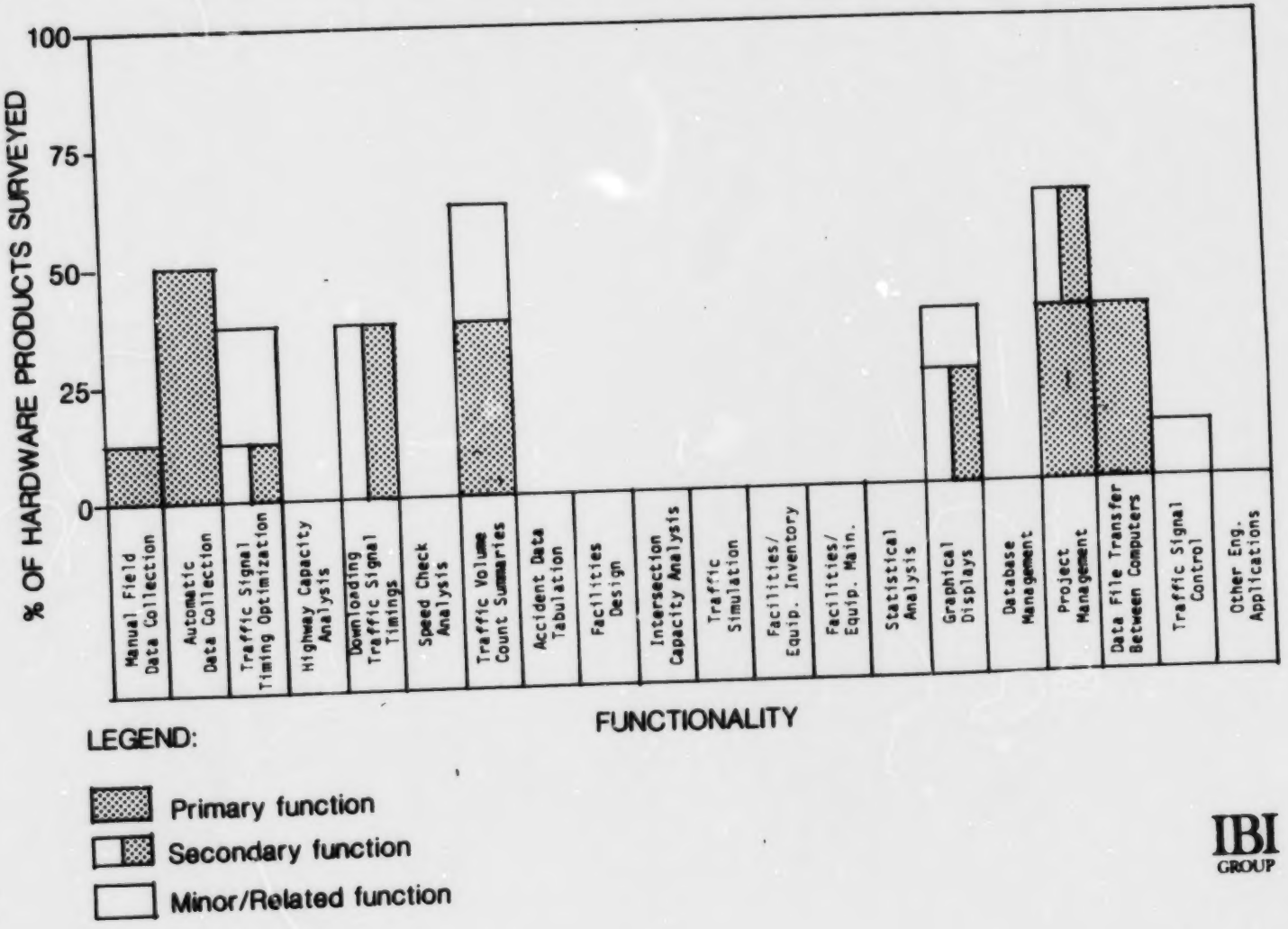

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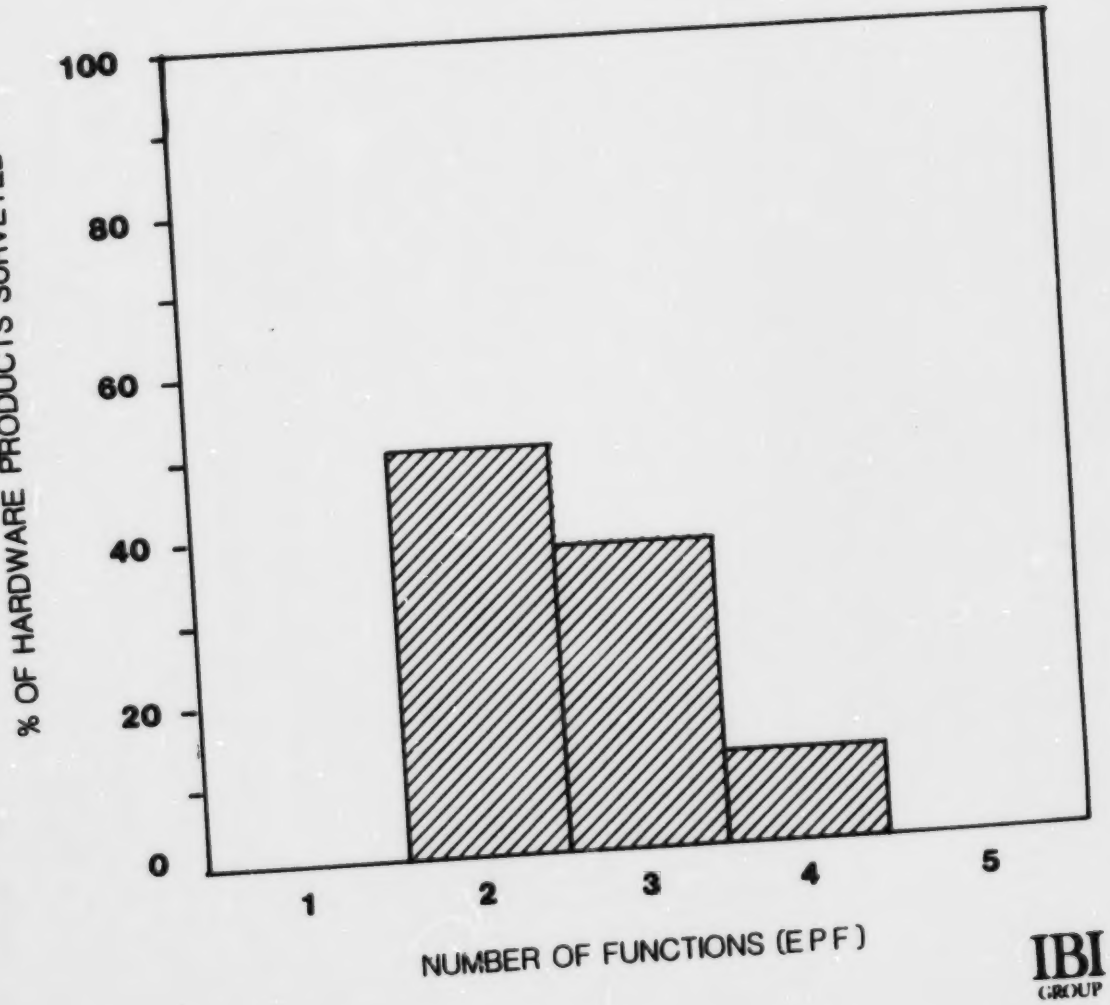
Exhibit 2.3

HARDWARE VERSATILITY



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In summary it is evident that traffic analysis hardware have certain deficiencies:

- o limited functions. Most hardware surveyed concentrated on data collection and control. In the case of data collection there are further limitations in that most equipment deals with automatic counting; there are no good quality manual counters for intersection turning counts;
- o limited versatility. Except for the large traffic control systems, most hardware has limited versatility in that it only performs one or two functions. Moreover, for those systems with a software component, the software is usually proprietary with no source code. Therefore, it is not possible to alter the software in accordance with the unique needs of municipalities.

2.3. EXISTING TRAFFIC ANALYSIS SYSTEMS - SOFTWARE

2.3.1 Single Function Applications

Most of the current traffic engineering software packages are single function programs which have been developed for a specific task. Examples of single function applications include:

- o capacity calculators;
- o single intersection design and evaluation;
- o arterial systems design and evaluation;
- o inventory applications; and
- o accident record systems.

Capacity calculation programs are generally concerned with roadway capacity, capacity at freeway bottlenecks (e.g. merging areas, weaving areas) and signalized intersection capacity. Roadway and intersection capacity programs such as CAPCALC are often based on the highway capacity manual methodology (TRB Circular 212).

Intersection design and evaluation programs such as SOAP often deal with computing optimal cycle lengths and signal timing splits. These programs evaluate the effect of a specified signal plan on measures of effectiveness such as stops, delay, and fuel consumption. These software packages can be an important supplement to capacity evaluation programs because they provide valuable information by which to evaluate capacities.

The PASSER II program is one example of an arterial signal timing design and evaluation package. These programs were developed to determine optimal traffic signal timing for an arterial street where progression is desired. Signal coordination is achieved by optimizing cycle length, phasing, splits and offsets for the arterial corridor in question.

Microcomputer software packages for inventory applications require the use of a data base management system (DBMS). These DBMS systems often possess extensive management capabilities (e.g. searching, sorting, merging, inquiring) and comprehensive report generation capabilities. There are several DBMS systems on the market today which can be used to provide effective data storage for signal systems, road sections and lighting equipment inventories.

A traffic accident record system is another example of an application ideally suited to DBMS systems. The microcomputer, combined with a 10 megabyte hard disk, provides an efficient accident record system for small to medium sized municipalities, as up to 100,000 accidents can be stored with no difficulty. The McTARS system (i.e. Microcomputer for City/Country Traffic Accident Record System) which operates on a Hewlett Packard microcomputer (HP150) is one example of a functional system.

In summary, it should be noted that many of the single function application programs (eg. PASSER II) were originally developed for main-frame systems. Recently many of these programs have been transferred to a microcomputer environment; however, most programs still operate in an independent mode (i.e. no data file sharing with other programs or other work stations).

2.3.2 Multi-Function Applications

Multi-function software applications identified by the survey include the following packages:

- o TEAPAC (traffic engineering application package);
- o ITDS (integrated traffic data system);
- o urban network/freeway corridor simulation models.

TEAPAC, a proprietary software package which was developed by Barton Aschman, presents one attempt at developing an integrated analysis package. This package which consists of over 20 programs, covers a wide range of basic traffic engineering analysis and design procedures. Typical analysis programs include capacity analysis, traffic survey summaries, and air quality analysis. Although the TEAPAC software is geared towards analysis and design of traffic systems, this package has a number of inherent restrictions/limitations which include:

1. The cost of the total package is approximately $26,000 U.S. which may prove prohibitive to smaller municipalities.
2. Although many of the basic analysis functions are fulfilled, TEAPAC still does not represent a comprehensive traffic analysis system.
3. No definable front end (hardware/software) for data collection has been developed.
4. The current package is only available under the CP/M operating system.

ITDS, which was developed by the FHWA, is a microcomputer software package for maintaining a traffic engineering data base. This system permits the traffic analyst to interface with existing simulation and signal timing optimization models (i.e. NETSIM and TRANSYT). The package utilizes a commercially developed data base management module;

however, the screen handler, the card formatter and the data base editor were developed with the PASCAL programming language. The conceptual strengths of the ITDS system include integration, non-proprietory programs and standardized data elements. Within a functional context, however, ITDS is not a comprehensive product as this system is focussed towards traffic modeling as opposed to overall traffic operations. An in-depth analysis of the ITDS package is presented in Chapter 5.

A third group of applications which may be considered as multi-functional software include traffic models such as NETSIM and TRANSYT. Traffic simulation models have been under development by many researchers for almost three decades. These models can estimate the relative loadings on a given link for a given level of traffic demand as identified by a specified OD matrix. Freeway corridor models which simulate traffic on freeways were developed to evaluate surveillance and control strategies for freeway operations. Required input may include flows at the source and sink links, OD tables by time period and vehicle occupancy levels while common outputs include travel time, measures of delay, fuel consumption and vehicle emissions. The initial efforts have concentrated on applications within the mainframe computer environment; however, in recent years, several mainframe models have been adapted/modified for the microcomputer.

2.3.3 Software Evaluation

Software functionality with regards to traffic engineering applications is summarized in graphical form in Exhibit 2.4. A cumulative total of primary, secondary and related functions were identified for each function. The bar graph indicates that software systems are available for a wide range of applications; however, there seems to be a deficiency of programs for accident tabulation, equipment inventory and maintenance, and traffic signal control.

EXHIBIT 2.4

SUMMARY OF SOFTWARE FUNCTIONALITY

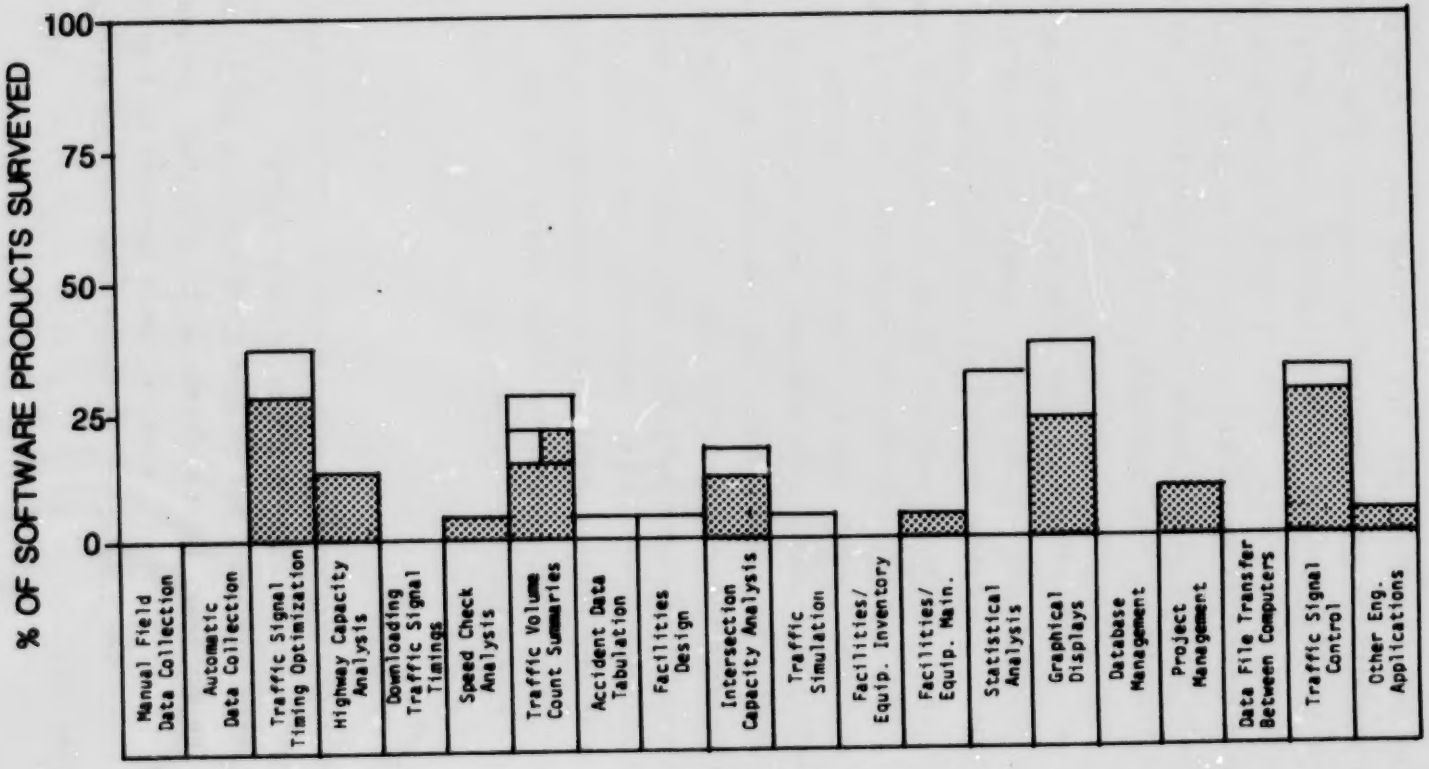

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Exhibit 2.5 presents a histogram identifying software versatility with respect to traffic applications. The graph indicates that the majority of the available software packages are single function applications which have been developed for a specific task.

2.4 Summary and Conclusions

The following is a summary of conclusions derived from the survey of existing traffic analysis systems:

Hardware

1. Hardware systems can be classified into on-site and centralized data collection systems and traffic control systems.

2. The current trends in hardware systems include the capability for transferring data directly into a microcomputer through an RS232 interface.

3. The existing hardware systems are generally proprietary in nature (i.e. system blueprints and/or source codes are not available).

4. Hardware functionality with regards to traffic engineering applications is generally limited to data collection, traffic signal operations, volume count summaries and data base management/data file transfers.

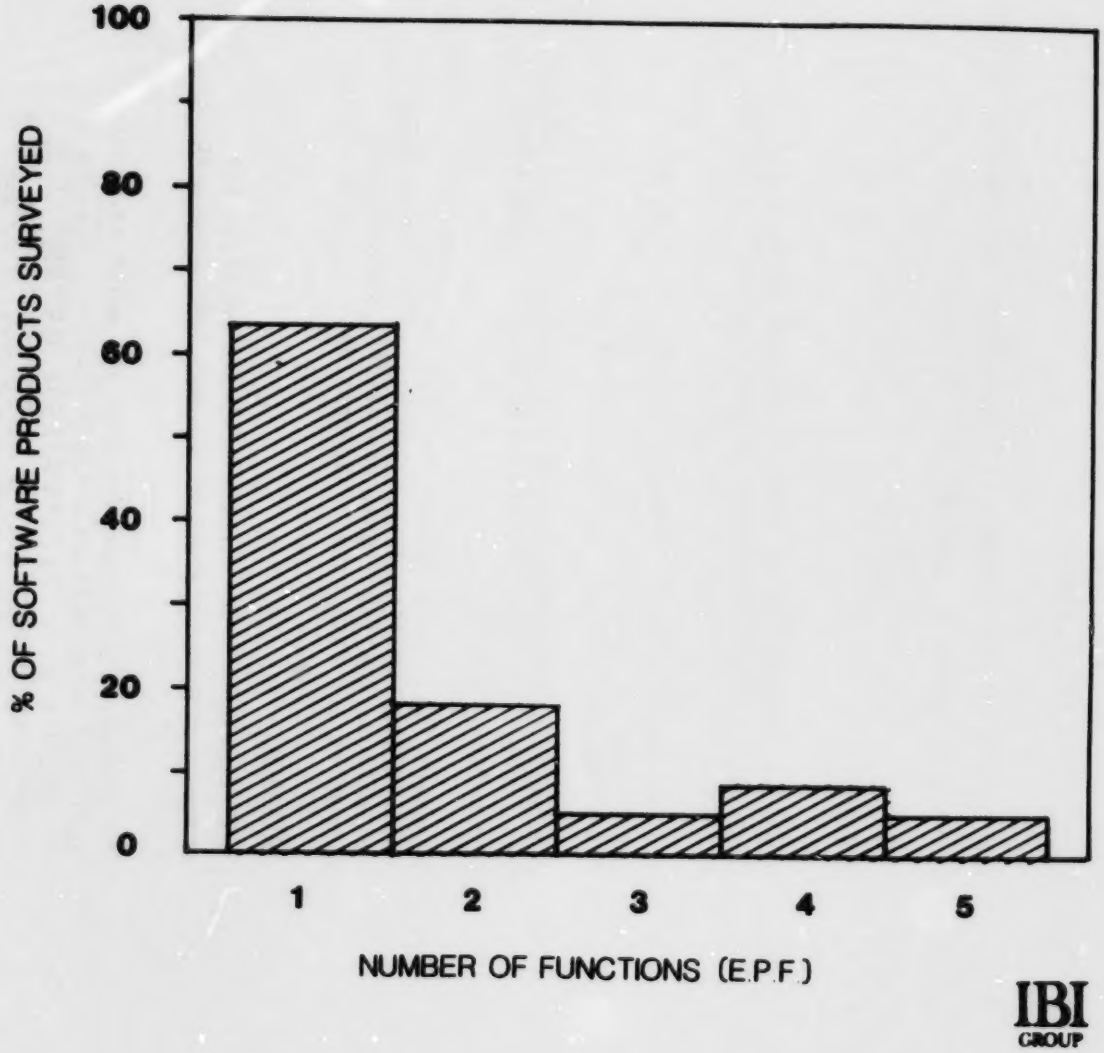
Software

1. The majority of the current software packages are single function programs which have been developed for a specific task.

2. The current single function programs which have been developed under different microcomputer/operating systems are generally incompatible with each other. Interfacing output from one program to provide direct input to a second would be very difficult if not impossible. In addition, software programs are generally proprietary in nature, as the source codes are not available.

Exhibit 2.5

SOFTWARE VERSATILITY



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3. The current multi-function application programs such as TEAPAC and ITDS are not comprehensive, in terms of providing the traffic engineer with a complete and efficient package. These systems, however, provide a foundation for future development of a comprehensive integrated traffic analysis system.

3.0 MARKET REQUIREMENTS

3.1 USER SURVEY

The previous chapter dealt with traffic engineering hardware and software available from suppliers. In addressing the need for a more comprehensive and integrated traffic analysis capability, a survey was taken of traffic engineering agencies to determine their needs. From the results of this survey, a comparison was made with the products available from suppliers and an assessment made of the product deficiencies. The survey was directed at traffic engineering practitioners at the municipal and provincial level with representatives selected from across Canada. The agencies surveyed are listed in Exhibit 3.1.

A questionnaire was prepared (Appendix B) and distributed to each of the agencies. The questionnaire was structured to:

- o determine the nature and frequency of special studies and surveys conducted by traffic engineering agencies;
- o the use and associated cost of computer services. Of particular interest is the potential to which a new micro-based system might provide a substitute for current charges;
- o the make, model and relevant characteristics of micro-computer equipment. This information is important in assessing the development environment for any new system;
- o the major functional areas of staff activities where an integrated traffic analysis system would be most beneficial;
- o the price that the traffic agency would be willing to pay for an integrated system. This was considered important because it can be considered an important measurement of the utility of an integrated analysis system.

EXHIBIT 3.1

LIST OF SURVEYED AGENCIES RESPONDED

Ontario Ministry of Transportation and Communications
British Columbia Ministry of Transportation and Highways

Region of Durham
Region of Peel
Regional Municipality of Ottawa-Carleton
Regional Municipality of Waterloo
Metro Toronto (Traffic Control Centre)

City of Brampton
City of Brantford
City of Burlington
City of Hamilton
City of Montreal
City of North Bay
City of Sault Ste. Marie
City of Winnipeg

As evident in reviewing Exhibit 3.1, there is a broad range of users surveyed, ranging in population of less than 100,000 to over 3 million with a wide variety of unique requirements. As such, it was concluded at the outset that the responses from these agencies would provide a reasonable representation of the major users across Canada. By way of information, there are approximately 40 cities in excess of 50,000 population who could make use of an integrated traffic system. In addition, there is a need for an integrated traffic system in a number of provincial government departments and divisions. Thus there could be a very sizeable market and need for such a system. It was felt that a survey of all potential users was beyond the time and scope of this study and that the sample of 15 would suffice, supplemented by the advice and input provided by the technical representatives on the Steering Committee. This latter element was especially important because it was through the Steering Committee meetings that the various needs and issues could be aired and discussed properly.

3.2. SURVEY RESULTS

Exhibit 3.2 provides a graphical representation of the survey responses denoting:

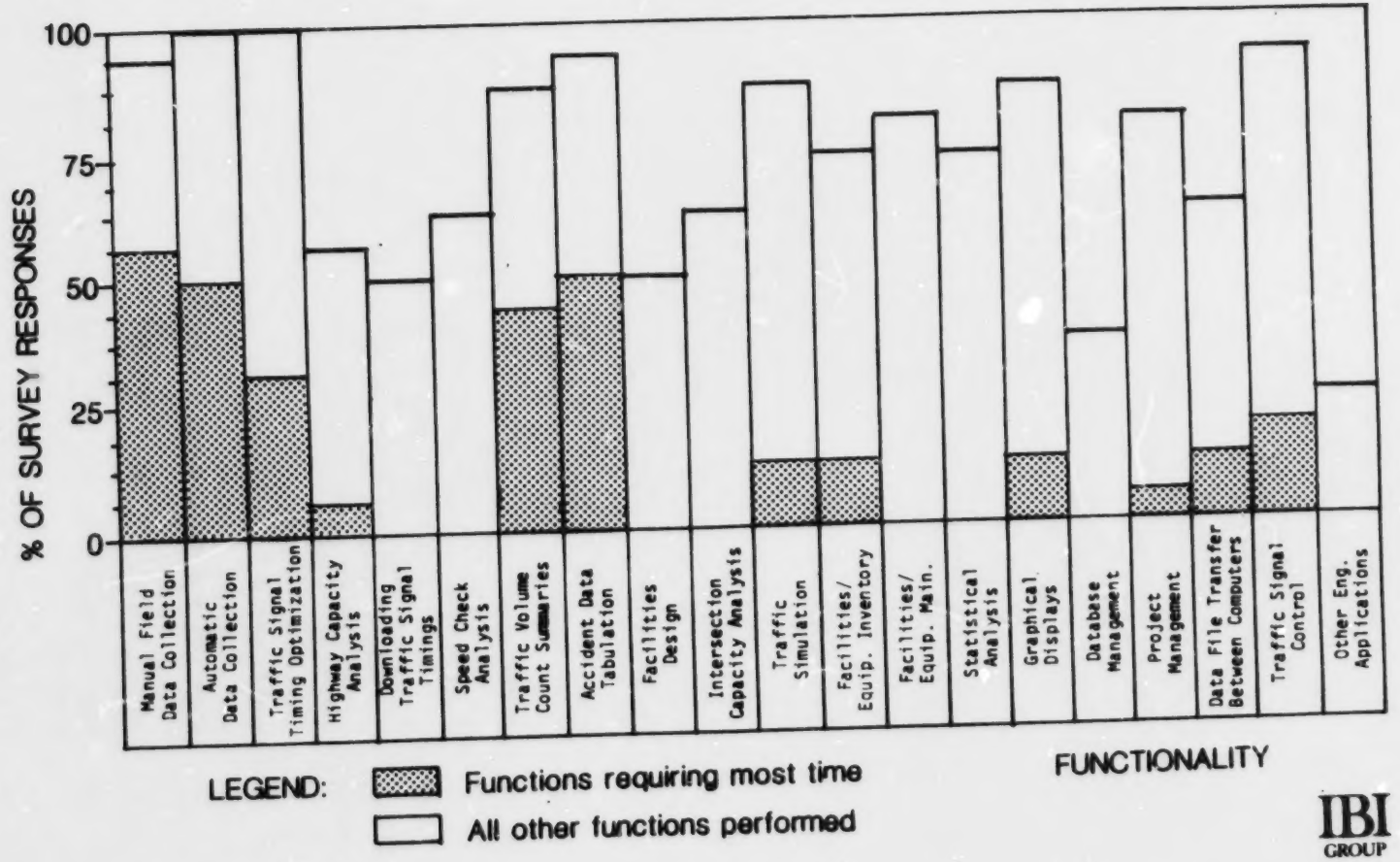
- functions performed;
- functions requiring most time.

There are a number of observations in reviewing the exhibit:

- the functions performed by the agencies surveyed is quite diverse, covering some 20 activities. With the exception of one or two areas, a minimum of half of all respondents indicated performing functions in any one area with many functions being conducted by virtually all respondents;

EXHIBIT 3.2

SUMMARY OF USER RESPONSES



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- the functions requiring the most time and therefore having some priority are clustered. Upon further analysis, it is apparent that the clustering is even more pronounced when various related activities are combined (eg. manual field collection, and automatic data collection);
- when the functions are grouped, the priority requirements would be as follows:
  - data collection and tabulation;
  - signal timing and capacity analysis;
  - accident data tabulation;
  - equipment inventories;
  - traffic signal control;
- the priority functions vary somewhat from city to city, reflecting size of the city as well as the present level of traffic signal control and the availability of computer resources. For example, one city identified equipment inventory as being a high priority but manual field and data collection as being a low priority which is at odds with the norm in terms of the other cities. This reflects the degree of sophistication in this city and the developments that have occurred to date.

After some discussion with the Steering Committee, certain priorities were established with respect to the general functional areas. The priorities reflected both the existing commitment of staff time and financial resources as well as the opportunity for direct and indirect savings. The resulting priorities were as follows:

- the accident tabulation and reporting;
- data collection tabulation and reporting;
- traffic analysis capabilities;
- signal equipment inventory and maintenance management system;
- traffic control.

Because of the interdependence and close relationship between data collection/tabulation and capacity analysis, the functional areas were subsequently grouped under the major heading of traffic operations which would include data collection and tabulating, signal timing, capacity analysis, etc.

3.3 COMPARISON WITH HARDWARE/SOFTWARE SUPPLIERS

In comparing the identified requirements of the market place with that available from hardware and software suppliers, there are a number of points that can be made:

- the hardware systems generally consist of traffic volume count equipment with some post processing and tabulation. Thus, the hardware does not satisfy the full data collection processing requirements especially as it relates to intersection counts;
- there are little or no accident analysis tabulation programs from any of the suppliers. This may reflect the diverse nature of the market place where each municipality or each major jurisdiction (eg. province, state, etc.) may have a unique accident reporting and summary system. This is an important priority of an integrated traffic system, because of the extent to which it is used by municipalities and the possibilities of incorporating the output into various other analysis;
- the priorities related to the market place are not coincident with what is available from suppliers. This is especially so given that the hardware and software available from suppliers is usually very limited (eg. one or two functions) and is proprietary, thus limiting the degree to which the hardware/software can be adapted and integrated.

3.4 OTHER SURVEY FINDINGS

One of the major questions on the survey was that of the perceived value of an Integrated Traffic System to address either all of

their functions needs or their most demanding needs. As noted in the survey form, this was referenced directly as "what price would you be willing to pay for an integrated system to provide the above functions".

The results of the survey are quite interesting, reflecting the broad range of interpretations and understanding. For example:

- one municipality argued very strongly that such a package should be developed by more senior levels of government and made available to municipalities and other key user agencies because of the national benefits that would be derived in terms of energy consumption, reduced delay, reduced pollution, etc.;
- one municipality was not willing to pay any funds for a system because they felt that they had or could develop any other system requirements in-house. (Note: no assessment was undertaken of the in-house development costs.);
- for those municipalities that responded to the question, the range for the priority items was typically between $3,000 and $6,000 with one agency suggesting $1,000 and another suggesting $150,000. The latter reflects the priority that has been given to such a system by one municipality;
- for a complete system that addressed all of the functional needs, the range in price was as low as $3,000 to $5,000, but more typically in the range of $8,000 to $20,000.

Based on the above, it could be argued that there is an intrinsic value to the development of such a system that would be a product of the average price that agencies would be willing to pay and the total number of agencies that would be willing to purchase such a system. If it is assumed that each municipality over 10,000 in population purchased one copy of the system at $6,000 per copy, $240,000 in development costs could be recouped. (Note: this does not include provincial government departments and divisions nor private sector users such as consultants.)

Another important consideration in the utility of an Integrated Traffic System is the degree to which existing computer-related charges could be offset. Exhibit 3.3 illustrates the responses related to annual computer costs. In reviewing the exhibit, it is apparent that the range is quite significant with two distinct groupings;

- o two municipalities have computer charges in the range of $40,000 to $50,000 a year;
- o the remaining municipalities have annual computer charges in the range of $8,000 to $12,000 a year.

It is evident that if the majority of these charges were applied to a microcomputer system, they would more than pay for such a system within one year.

The one last item of interest in the survey is related to the computer systems presently in use. It is evident that the IBM PC/XT/AT is the most popular microcomputer hardware being used by approximately 60% of the agencies surveyed.

3.5 SUMMARY

In reviewing the market survey, there are a number of points to note:

- o the primary needs in the market place for an Integrated Traffic System are not now being satisfied by hardware and software vendors;
- o the priority requirements related to an Integrated Traffic System would consist of:
  - an accident tabulation recording system;
  - traffic operations function which would include data tabulation and analysis capabilities;
  - an inventory control system;

EXHIBIT 3.3

COMPUTER COST SUMMARY

	ANNUAL COMPUTER CHARGE/YEAR
Montreal	$ 50,000
Regional Municipality of Ottawa-Carleton	12,000
Ontario Ministry of Transportation & Communications	117,000*
North Bay	12,000
Hamilton	42,000
MTC Thunder Bay	..
Waterloo	11,000
Winnipeg	-
B.C. Ministry of Transportation & Highways	12,000
Sault Ste. Marie	-

* MTC Head Office Computer Budget (1985/86)

- a traffic signal control capability;

- o most users surveyed indicated that they would be willing to pay between $5,000 and $15,000 for a Integrated Traffic System so long as it satisfied their practices and procedures;

- o in many municipalities, the cost of the hardware and software for an integrated traffic system could be covered in the first year of operation by simply replacing leased or time-share services;

- o the dominant microcomputer based hardware used by municipalities is the IBM system with the MS DOS operating system.

4.0 INTEGRATED TRAFFIC SYSTEM REQUIREMENTS

4.1 SURVEY FINDINGS

From the survey of traffic agencies as well as a survey of suppliers for hardware and software, it is apparent that there is a need for a multi-functional integrated traffic analysis system that allows traffic agencies to:

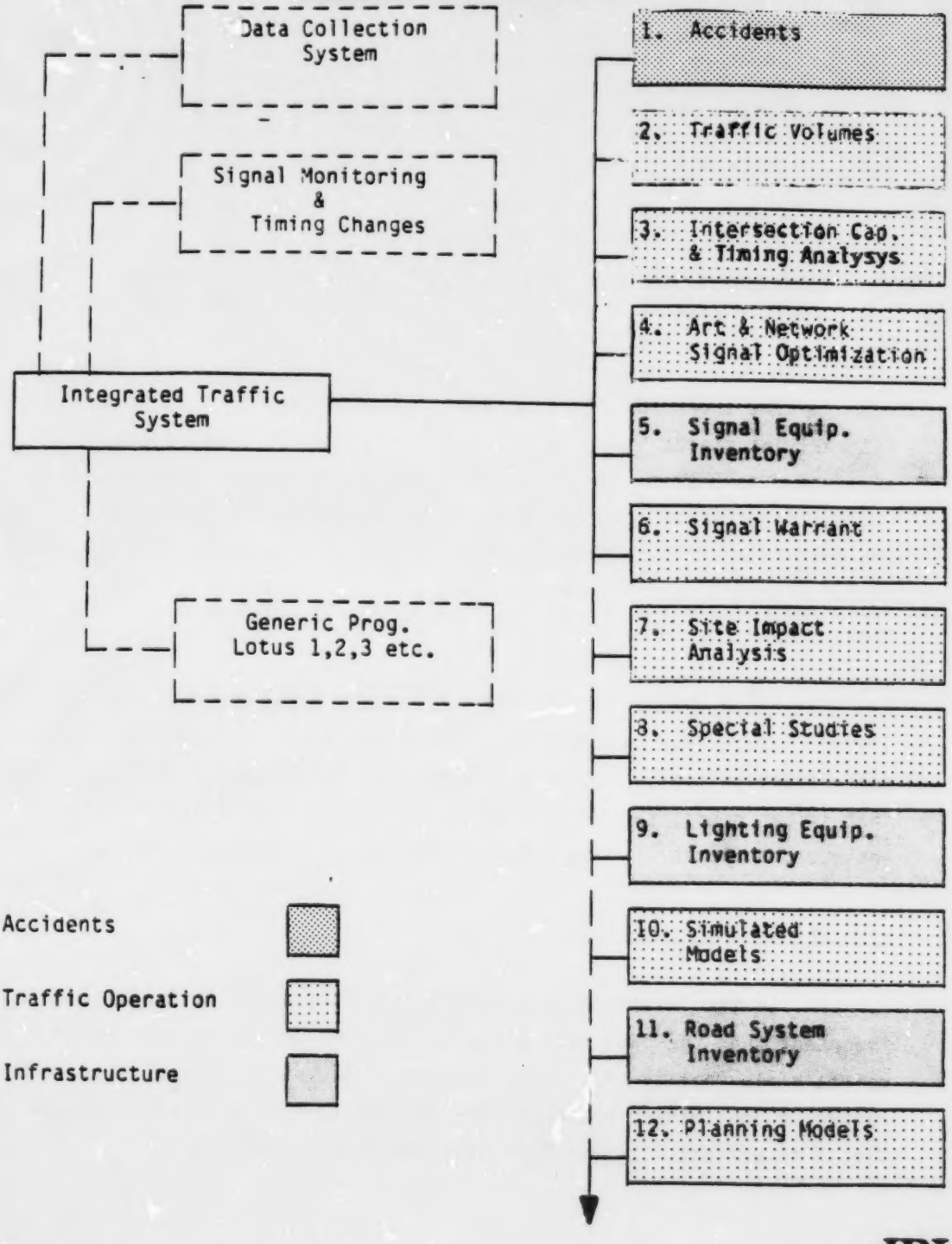
- o tabulate accident data;
- o conduct traffic operations/analysis including the tabulation of data;
- o maintain equipment inventories.

It is apparent from the survey that the needs of users vary considerably and that any system that is developed must incorporate flexibility so as to allow a wide variety of analysis programs to be incorporated into the system. This flexibility is required to achieve wide scale acceptance and the important economies of scale that are required in such a market place. In addition, if the system is flexible, it would increase the ability to adapt to new packages and programs as they are developed.

Based on the results of the survey of users, Exhibit 4.1 represents a schematic of an Integrated Traffic System (ITS). The main part of the program consists of the traffic analysis sub-system. Typically, these sub-programs can be classified into the three functional groups: accident analysis and reporting, traffic operations, and infrastructure inventories. Also evident in the exhibit, there are a number of external interfaces which include:

EXHIBIT 4.1

INTEGRATED TRAFFIC SYSTEM



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- o a data collection sub-system. (This data collection sub-system could consist of portable intersection counters, remote permanent counting stations, portable roadside volume counters, etc. The Integrated Traffic System should be designed to take account of any variety of external data sources so long as the interface is compatible.);
- o commercial software packages including spreadsheets, word processing and graphic programs;
- o a signal monitoring sub-system. This could include an interface to an existing traffic control system through which timings could be alterned.

The three functional groups of traffic analysis along with their external interfaces have traditionally required the development of separate data bases; however, within an integrated environment, these applications can be combined through the use of common data elements into one data base. This would allow one to identify standard data element characteristics so that compatibility can be maintained for future enhancements.

Based on the general requirements of an Integrated Traffic System, a data base management system (DBMS) would be a very efficient and cost-effective tool for such a system. The advantages of this approach is that it can significantly reduce the overall development cost and also enhance the flexibility to adapt to new analysis programs.

4.2 DATA ELEMENT LINKAGES

In the initial development of an Integrated Traffic System, it is important that the data base elements and linkages be identified so as to maintain flexibility for future enhancements. As an initial step in this regard, a preliminary review of the various traffic analysis programs listed in Exhibit 4.1 have been reviewed with respect to:

- o input requirements and sources;
- o analysis;
- o output including graphs and reports.

In addition, the data elements for both inputs and outputs for the listed applications were addressed. The results of this preliminary analysis are contained in Appendix C.

4.3 DATA FLOW INTERACTIONS

As has been noted in the survey of needs, one of the major requirements of an Integrated Traffic System is that of linking programs and their data elements so that output of one can be used as the input of anotner without manual intervention. An understanding of these linkages is required in developing the data base structure. A preliminary analysis of the data flows for a limited number of traffic analysis applications was performed. The following describes the data flow for two selected applications: signal warrants and network optimization.

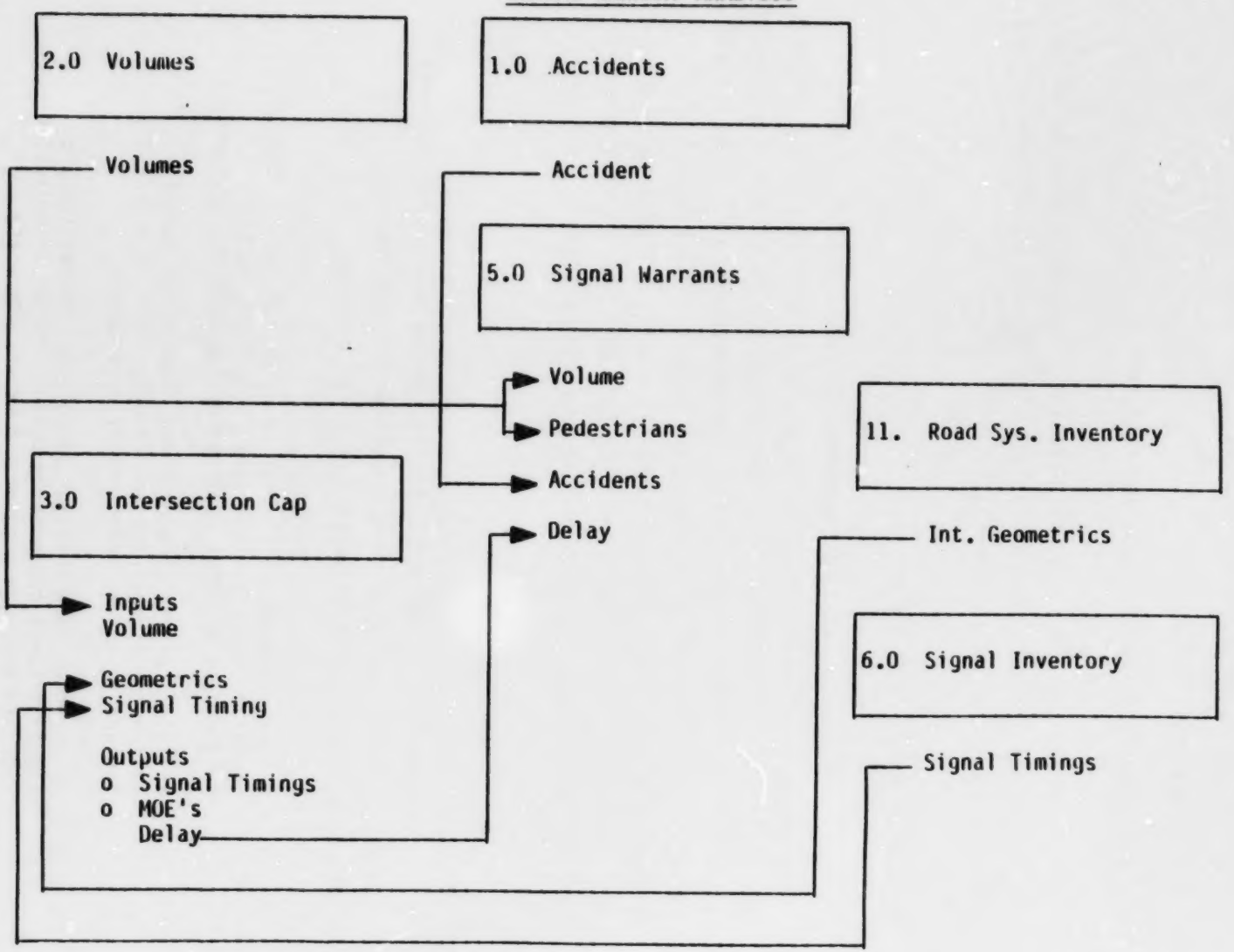
4.3.1 Signal Warrants

Exhibit 4.2 highlights the linkages between signal warrants analysis and various other traffic engineering applications. The following provides a brief summary of these linkages:

- o volume and pedestrian data are required directly for signal warrants but the same information is also required as an input to intersection capacity analysis;
- o accident rates and records are required as justification for signals and accordingly there is a direct linkage to the accident reporting program;
- o delay which is a function of volumes, geometrics and signal timings could be an output from an intersection capacity analysis program. However, there are secondary linkages from intersection capacity back to the volume, road inventory and signal inventory files.

EXHIBIT 4.2

DATA FLOW LINKAGES FOR
SIGNAL WARRANT ANALYSIS



4.3.2 Arterial and Network Capacity Analysis

The optimization of flows through a road network and/or arterial often involves the use of a traffic simulation/optimization package such as TRANSYT. These models are generally data-intensive packages which require such information as intersection geometrics, signal timings, volumes, link characteristics and system parameters. Exhibit 4.3 identifies the possible linkages between the input file of a traffic model and various other traffic analysis applications. A brief review of these linkages are summarized as follows:

- a road system inventory provides the physical intersection and link characteristics for the traffic model;
- signal timings could be obtained from an intersection capacity and timing program which may have obtained its input from both the road system and signal equipment inventories;
- volume and pedestrian data classified by time period and day would provide essential input to both the network optimization and signal timing programs.

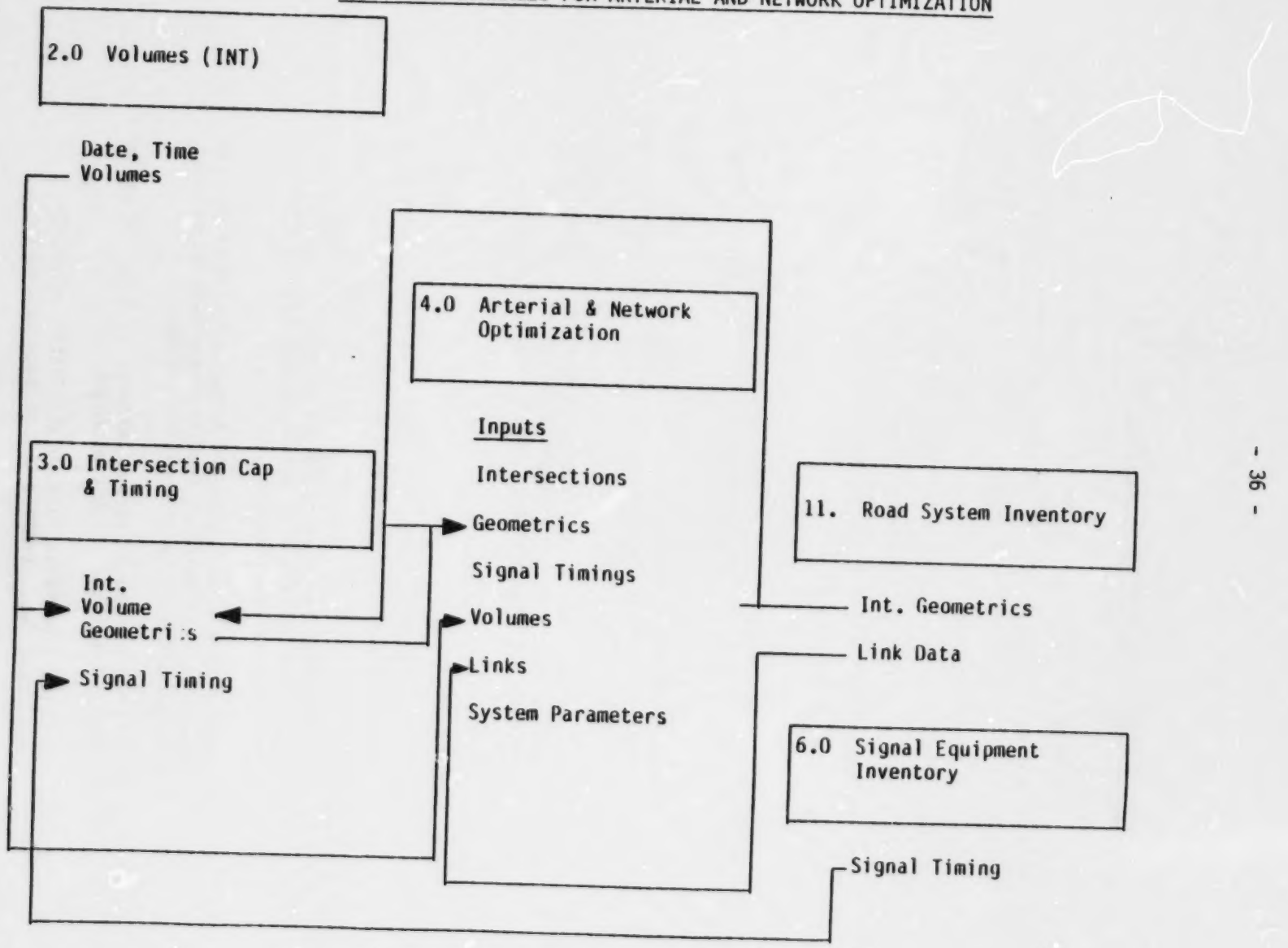
4.4 CONCLUSIONS

An integrated traffic analysis system must:

- be flexible in order to adjust to a wide variety of needs and users and to adjust to new application programs as they develop;
- have a data base design and structure that recognizes the interrelationships and interdependencies of the inputs and outputs of analysis packages;
- incorporate and integrate features such as the use of spreadsheets and graphic packages;
- include interfaces to automatic data collection equipment (eg. traffic volume data collection).

EXHIBIT 4.3

DATA FLOW LINKAGES FOR ARTERIAL AND NETWORK OPTIMIZATION



5.0 SYSTEM DESIGN

5.1 DESIGN CONSIDERATIONS

In the development of an Integrated Traffic System one must consider the functions and applications which should be available to the users. Traffic engineering applications can be divided into a number of discrete tasks which include:

- o data collection;
- o data storage;
- o data retrieval;
- o data output;
- o data analysis.

Traditionally the first three tasks (i.e. collection, storage and retrieval) have consumed the major portion of the traffic analyst's time. This ultimately leaves very little time or resources for traffic engineering analysis/decision-making.

In our assessment of system requirements, it was noted that the above mentioned tasks are applied in three main functional areas of traffic application:

1. Traffic accident records;
2. Traffic operations/analysis;
3. Infrastructure inventory.

The continuing advances in microcomputer technology however offer an effective and efficient approach to automating the time-consuming tasks of traffic engineering. The data required for the three main functions of traffic engineering indicated above could be effectively integrated within a common data base through the use of a microcomputer and a data base management system (DBMS). This data base management system would represent the central coordinating module through which various input and output facilities could be interfaced to form a complete and comprehensive system to support the traffic engineer.

The data base management system provides the core upon which an integrated traffic system can be developed. The data base management system, which would be selected from one of the several currently available, would provide for the linkage between existing stand-alone traffic analysis packages and the various computer hardware offerings available in the market place. As well as providing a common data storage technique the data base management package must possess the following minimum capabilities:

- o on-line data inquiry/data entry facilities;
- o error checking facilities;
- o report writing capabilities;
- o system maintenance/revision facilities.

The results of the survey undertaken in this study indicate that the predominant computer hardware and software environment available to the traffic engineer today consists of an IBM PC (or compatible) utilizing the MS-DOS operating system. This situation is in keeping with the industry-wide trend towards this form of hardware.

For the sake of our analysis we have assumed that the hardware environment for the integrated traffic analysis system would be an IBM PC/XT/AT microcomputer or compatible, with random access memory (RAM) of 512,000 bytes and hard disk storage of 10 to 20 million bytes. Peripheral hardware would include a monitor and printer along with optional modems, plotters and multi-user terminals.

In any proposed system development, the designer must take due consideration of the advances to be expected in computer hardware and software technologies through the expected lifecycle of the system. The hardware described above constitutes the standard microcomputer environment available today. The large variety of hardware and software enhancements made available on a month by month basis for this technology would indicate that it will maintain its role as the industry standard for a period of 2-5 years. The selection of computer software tools to be utilized in an Integrated Traffic System (ITS) development should be predicated on the software's ability to grow in both features and functionality. It can be expected that in the next two years the IBM PC based hardware will be capable of supporting a multi-user environment through either expanded computer capabilities or through networking of microcomputers. This multi-user capability will grow in importance for the integrated traffic system through its own lifecycle.

5.2 ASSESSMENT OF ITDS

The Integrated Traffic Data System, (ITDS) has been developed at the Oakridge National Laboratories under funding of the FHWA over the period of the last four years. The ITDS system represents one attempt at developing a data base module for storing traffic engineering data. The obvious design criteria exhibited in this package include a functional integration of data, non-proprietary program, and a standardization of data elements. The ITDS development focussed on the integration of the data requirements for traffic system models (i.e. NETSIM and TRANSYT) as opposed to the data requirements of overall traffic operations. The conceptual strengths of the ITDS system, especially as they are depicted

in the data base schema proposed for the complete package, must be acknowledged as a major thrust in advancing the field of traffic engineering. However, it must be noted that functionally, through its design, the ITDS system is not a comprehensive product that can be installed in a traffic engineering office within a municipality and be expected to provide for the overall data storage and analysis needs.

Upon initial examination of the ITDS system and its source code, it was concluded that it would be possible to interface individual external modules to the ITDS system to make it a more complete product. However, after an in-depth review, it was concluded that there were a number of technical considerations which would make this process less attractive than other alternatives. These technical considerations are summarized below:

1. ITDS was developed for the IBM PC utilizing the CPM-86 operating system and the MDBS-III data base management module. The MS-DOS operating system has overtaken the CPM-86 operating system as the current industry standard and the conversion of ITDS to run under MS-DOS while currently underway will delay its availability for some time. The MDBS-III data base management system, while being a very comprehensive tool again has not become an industry standard. In addition only one small portion of the MDBS-III package was utilized in this implementation.

2. The ITDS system utilizes a standard data base management system module (MDBS-III) as the core of its software system. However, due to the availability of the other user interface portions of the MDBS-III package, the screen handler, the card deck formatter, and the data base editor included in the ITDS system were all developed utilizing the PASCAL programming language. Any subsequent development enhancement or modification to these portions of the ITDS system would require major programming efforts.

3. The programming tools, i.e. data base package, operating system, programming language which were selected at the start of the ITDS project (i.e. early 1980's) are now outdated. The reimplementation of the ITDS system concept utilizing current software tools would take less effort than any modification to the existing ITDS system.

4. The ITDS system is still not yet available to the general public. The development/availability timeframe of ITDS may prove to be a major obstacle in the timely introduction of computerization into traffic engineering offices.

5. The ITDS package includes restrictions with regards to portability and transferability, as the source code for the screen handlers, formatters, etc., have not currently been provided. The absence of these source codes would limit the ability to interface new external analysis modules to the ITDS system.

Despite the difficulties, shortcomings and limitations of the ITDS system as noted above, this development activity has provided a firm basis for the introduction of microcomputers into traffic engineering applications. The conceptual framework on which the ITDS system was developed is sound. The data base schema designed for the ITDS provides the initial basis for a comprehensive traffic engineering data base. The concept of a central data base and interface modules to existing analysis packages is also to be recommended. Overall, the shortcomings of the ITDS system do not fall in the conceptual area but rather in the availability and selection of the microcomputer hardware and software tools utilized to implement the concept.

The following list summarizes the conclusions with regards to the ITDS package:

1. The concept of developing a centralized traffic engineering data base from which standardized data elements could be extracted for subsequent analysis/decision-making can be implemented very effectively in a microcomputer environment;

2. The ITDS system is not a comprehensive product as the major emphasis is on traffic simulation/modeling;

3. A number of technical and administrative considerations such as outdated programming tools and the development/availability timeframe of ITDS would make it infeasible/unattractive to modify or add on to the current package; and

4. The ITDS system is not transferable to a new software environment as a "stand-alone" system without a major rewrite.

5.3 ITS-CONCEPTUAL SYSTEM DESIGN

After a market analysis of desirable functional components, a comprehensive study of data element interactions and a detailed review of the ITDS system, a prototype Integrated Traffic System (ITS) was developed. This ITS system provides a means for consistent handling of data input and output across the traffic analysis programs. This system eliminates the need for users to remember different input formats and application specific parameters. In special instances, output from one program can be redirected as input into a second program. The ITS system is designed to solve the problems of user friendliness and compatibility between programs through the development of a menu driven front end facility and an integrated data base concept.

Exhibit 5.1 presents one approach in defining the user interface to the ITS system. This exhibit presents a partial structure of the system menus which drive the package. The "Level 0" menu permits the user to select the desired category of traffic applications. With each category, the "Level 1" menu presents the available system functions such as data entry, report preparation, file transfers and system maintenance. Upon selection of a given function, the "Level 2" menu identifies the available traffic analysis applications and/or external analysis interfaces. By implementing a menu hierarchy of this nature, one could essentially use the system without requiring prior knowledge of operating system command, program-specific commands or interface requirements.

The key to the flexibility and power of ITS is the fact that it is built around a true relational data base management system. Within a relational data base system, the query facilities can employ any

relationship that exists between files at any time. Although the relational data base provides the facilities to join multiple files and/or fields, the information should be stored in a format that allows the data base software to answer questions quickly and to produce reports efficiently. The ITS data base was therefore initially developed in a modular fashion; however, a number of logical joins have also been incorporated within the system.

The system requirement task as documented in Chapter 4 identified three categories of applications which are deemed essential to the traffic engineer. Exhibit 5.2 presents the ITS data base schema which identifies all the relevant files and their associated logical connections which allows one to combine the three functional categories into one data base. Exhibit 5.3 presents the list of ITS files along with a file description and their associated subsystems. The ITS data base was designed to provide a means for storing the traffic data required to run all necessary traffic applications; however, the system is also capable of incorporating changes in the data base structure for future enhancements.

5.3.1 Traffic Operations/Analysis Subschema

Exhibit 5.4 identifies the data base schema and logical connections within the traffic operations/analysis system. This subschema consists of network geometry files, signal timing files and link description files.

The NETWORK file identifies the various road networks within the system. A small municipality may employ a single network while medium to large municipalities would identify logical subnetworks within the road system. A road network is composed of a series of links and nodes. Links are defined as unidirectional road segments between two user defined nodes (usually intersections). A link may consist of any number of traffic lanes and includes left turning, right turning and through movements.

EXHIBIT 5.1

HIERARCHY OF SYSTEM MENUS

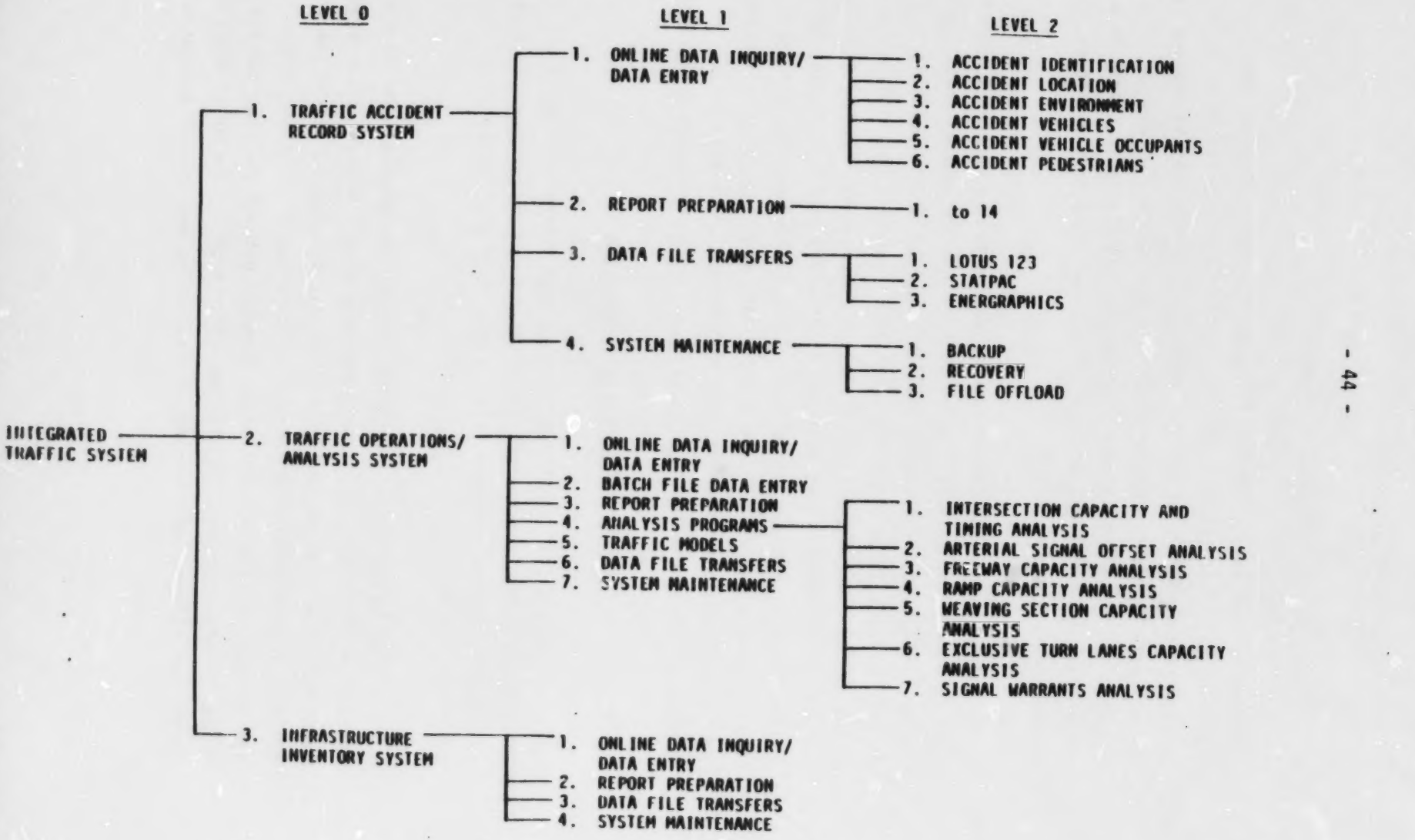
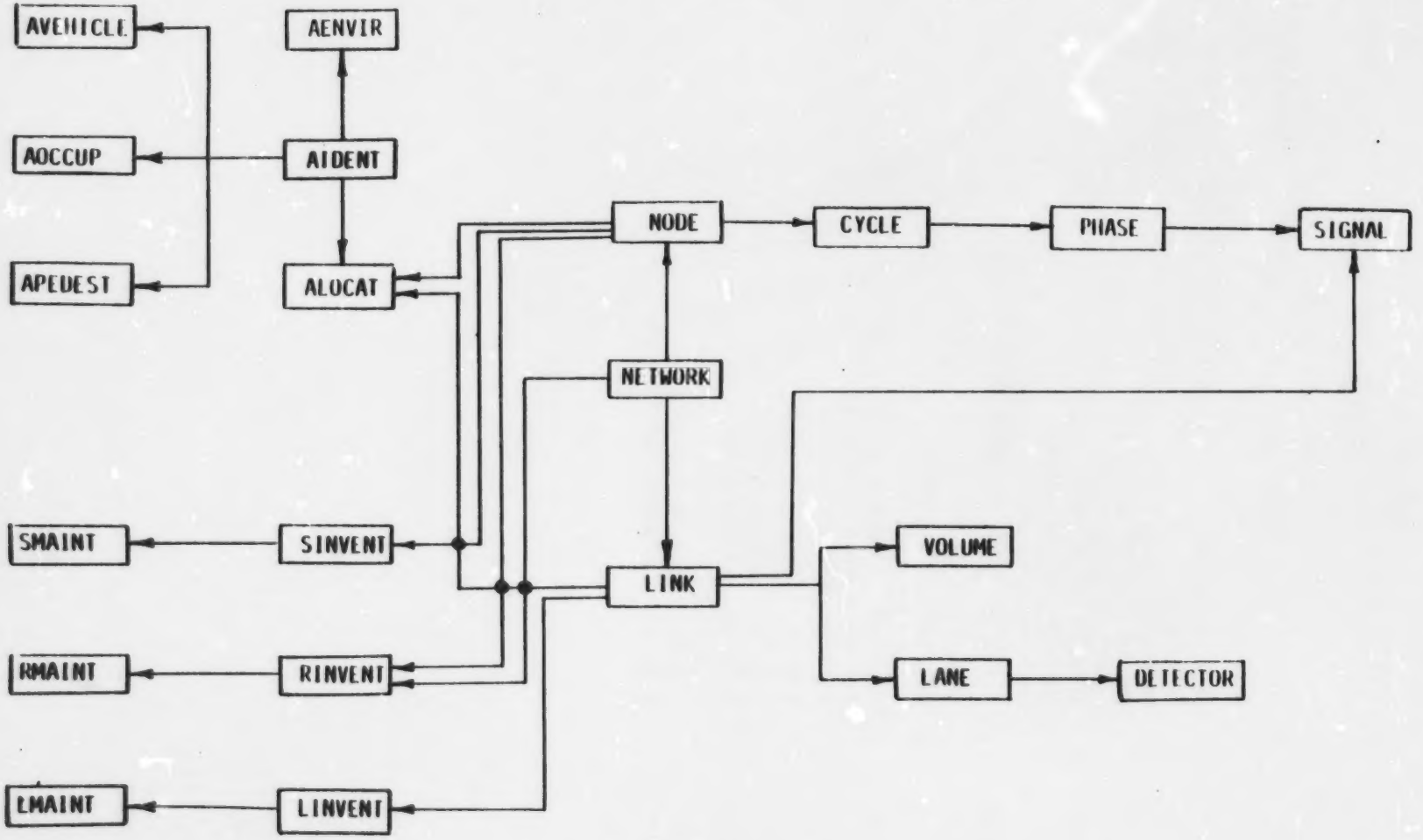


EXHIBIT 5.2



INTEGRATED TRAFFIC SYSTEM

LOGICAL DATA BASE OVERVIEW

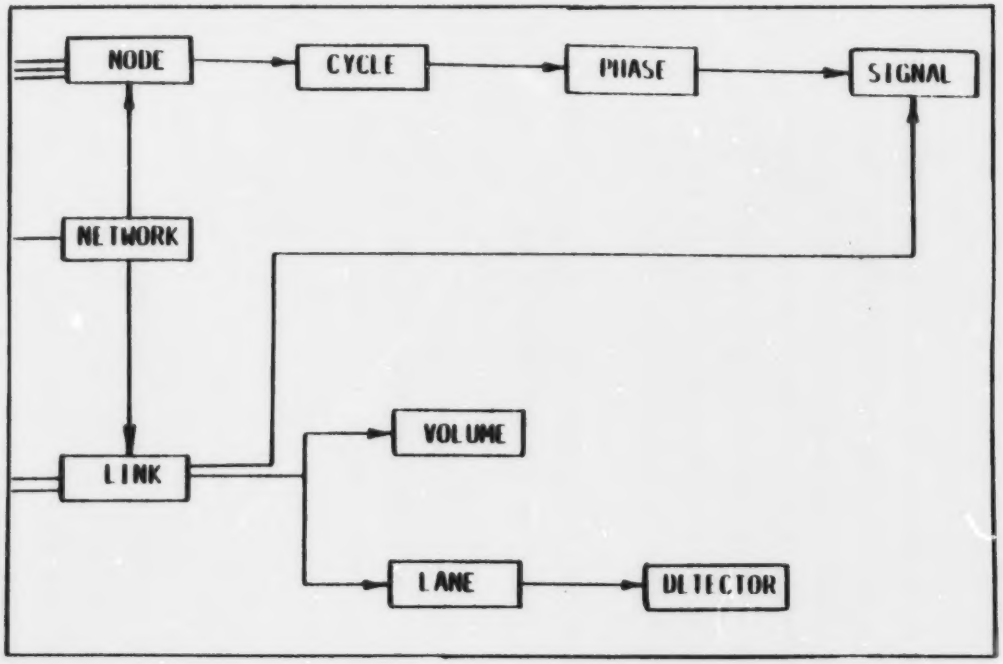
EXHIBIT 5.3

ITS DATA BASE

FILE	FILE DESCRIPTION	SUBSYSTEM
NETWORK	Network Master	TOAS, INIS
LINK	Link Master	TOAS, TARS, INIS
NODE	Node Link	TOAS, TARS, INIS
VOLUME	Volume Records by Link	TOAS
LANE	Lane Records by Link	TOAS
DETECTOR	Detector Records by Lane	TOAS
CYCLE	Cycle Records by Node	TOAS
PHASE	Phase Records by Cycle	TOAS
SIGNAL	Signal Records by Phase, Approach	TOAS
AIDENT	Accident Identification	TARS
AENVIR	Accident Environment	TARS
ALOCAT	Accident Location	TARS
AVEHICLE	Accident Vehicles	TARS
AOCCUP	Accident Vehicle Occupant	TARS
APEDEST	Accident Pedestrians	TARS
SINVENT	Signal Equipment Inventory	INIS
SMAINT	Signal Equipment Maintenance	INIS
RINVENT	Road Section Maintenance	INIS
RMAINT	Road Section Maintenance	INIS
LINVENT	Lighting Equipment Inventory	INIS
LMAINT	Lignting Equipment Maintenance	INIS

EXHIBIT 5.4

TRAFFIC OPERATIONS/
ANALYSIS SYSTEM



NETWORK - Network Master File

LINK - Link Master File

NODE - Node Master File

VOLUME - Associated with each link may be one or more volume records.

LANE - Each link may have one or more lane records.

DETECTOR - Each lane may have one or more detector records.

CYCLE - a controller at a node may have more than one cycle of operation.

PHASE - phase specific information is stored in this file.

SIGNAL - associated with each approach is some signal which is presented to approaching vehicles.

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Signal timing information is stored in three files and these are CYCLE, PHASE and SIGNAL. Each signalized intersection/node can have several associated cycles, as different cycle plans can be activated throughout a 24 hour period. Each cycle is divided into one or more phases which are used to control vehicle flow for one or more principle movements. The actual signal information that is presented to the approaching vehicles and/or pedestrians is stored in the SIGNAL file.

The VOLUME, LANE and DETECTOR files are used to describe each unique link. Each link can have any number of volume records corresponding to different vehicle counts at different times of the day. The LANE files identifies lane specific information such as lane width, lane designations (e.g. buses only) and the presence of detectors. Vehicle detector information (e.g. type of detector, location of detector) is stored in the DETECTOR file.

5.3.2 Traffic Accident Record Subschema

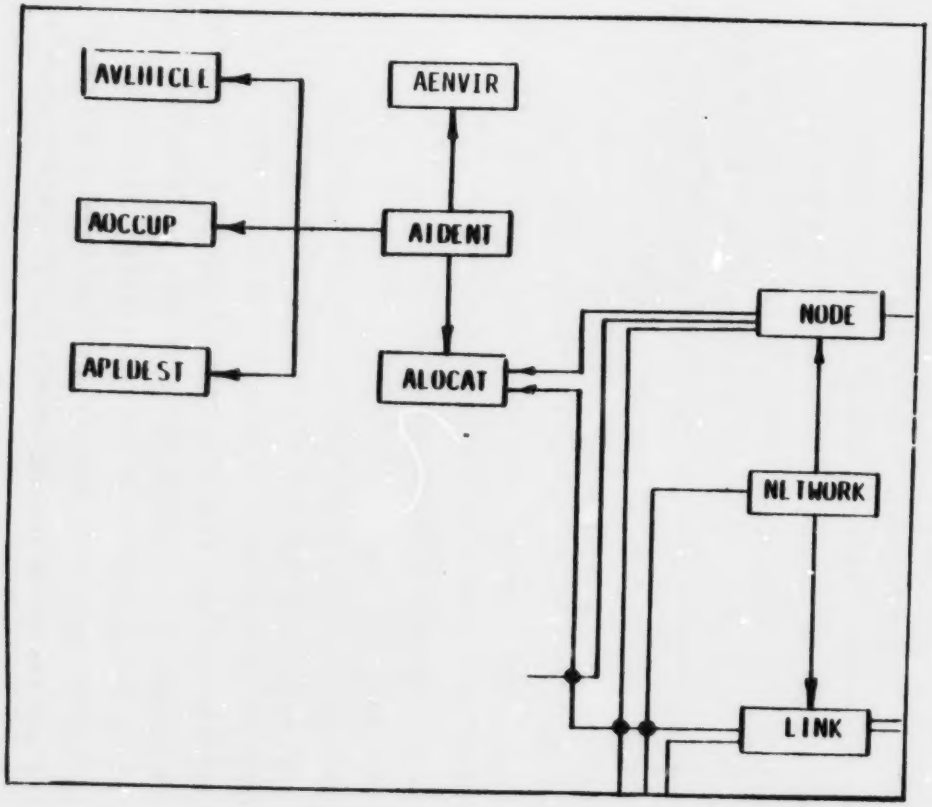
The traffic accident record subschema is presented in Exhibit 5.5. This sub system may be developed as a stand-alone inventory system; however, for traffic related applications such a signal warrants, it would be very advantageous to have a direct link with the accident records. The ITS system establishes this direct link by identifying the accident location through the use of a node-link descriptor.

The accident information is stored in six files which include: AIDENT, ALOCAT, AENVIR, AVEHICLE, AOCCUP and APEDEST. For each accident, single records are stored for accident identification, location and accident environment. One or more records can be maintained for accident vehicles, occupants within vehicles and pedestrians/cyclists.

5.3.3 Infrastructure Inventory Subscheme

The Road and Maintenance Departments within municipalities often manually maintain an inventory of equipment and facilities along with

EXHIBIT 5.5



NETWORK - Network Master File
LINK - Link Master File
NODE - Node Master File
AIDENT - Accident Identification File
AENVIR - Accident Environment File
ALOCAT - Accident Location File
AVEHICLE - Accident Vehicles File
AOCCUP - Accident Vehicle Occupants File
APEDEST - Accident Pedestrian File

TRAFFIC ACCIDENT
RECORD SYSTEM

IBI GROUP

their associated maintenance records. In developing a "complete" traffic engineering data base, this infrastructure inventory can be quite easily incorporated into the system in order to increase data handling and report generation efficiency. The inventory system is linked into the ITS system through the use of network, node and link descriptors.

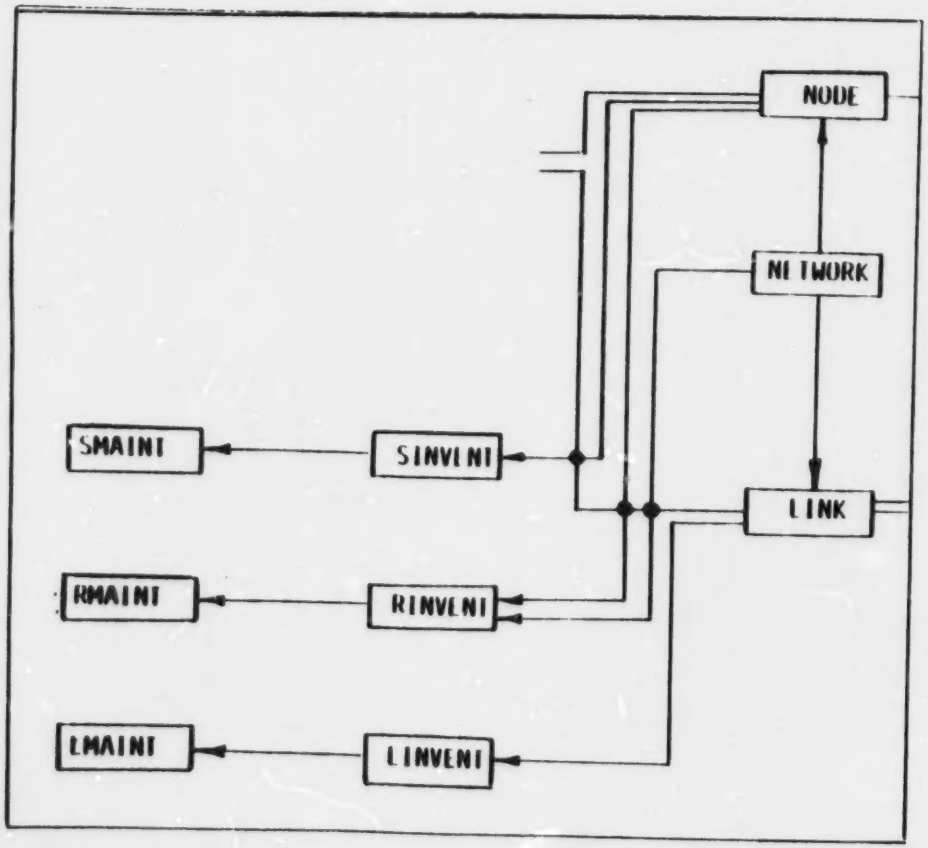
Exhibit 5.6 presents a logical overview of the infrastructure inventory subschema. Files have been created to maintain an inventory of signal equipment, road sections and lighting equipment. Furthermore, each inventory record may have one or more associated maintenance records.

5.4 ITS - SYSTEM HARDWARE REQUIREMENTS

The microcomputer system hardware requirements for the implementation of the Integrated Traffic System will vary depending upon the size of the municipality and the number of functions implemented within that municipality. The Integrated Traffic System, as a conceptual entity, should serve the needs of all sizes of municipalities throughout Canada. The very large municipalities, that is, those over 500,000 population will typically require a multi-user environment, a large traffic accident data base, and sophisticated traffic analysis models capability. The implementation of ITS in these municipalities might comprise either a large or mini computer capable of operating the ITS data base management software or a network of smaller microcomputer based analysis terminals (e.g. IBM PC) linked to a common network file server. A smaller municipality, that is, those under 100,000 population might only require a single microcomputer (e.g. IBM PC/XT). The design of the integrated traffic system is such that not all functional elements of the system need be implemented in any one municipality. In many large municipalities the traffic accident data base might already be implemented on existing mainframe computers. A choice could be made to leave the existing system in place or transfer it to the ITS system. Similarly, the use of sophisticated traffic models in smaller municipalities might be an infrequent occurrence and therefore the implementation of these aspects of

EXHIBIT 5.6

INFRASTRUCTURE INVENTORY SYSTEM



NETWORK - Network Master File

LINK - Link Master File

NODE - Mode Master File

SINVENT - Signal Equipment Inventory File

SMAINT - Signal Equipment Maintenance File

RINVENT - Road Section Inventory File

RMAINT - Road Section Maintenance File

LINVENT - Lighting Equipment Inventory File

LMAINT - Lighting Equipment Maintenance File

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the traffic operations and analysis system might not be necessary. In all municipalities, the size and extent of the road infrastructure on the choice system will depend upon the existing sophistication of the traffic office and the availability of the detailed infrastructure data. In all cases, it can be expected that the implementation of the Integrated Traffic System could occur in a staged manner, that is, those functions deemed most important to a particular municipality would be implemented first and as hardware capabilities and user needs warrant, additional functions could be added.

In all cases, the design of the Integrated Traffic System must give due regard to the rapid developments in the microcomputer technology and the availability of new peripheral equipment for data collection in the traffic engineering field. These considerations will predicate that the detailed design of the Integrated Traffic System be based on an open architecture, i.e. open for improvements and enhancements over the years.

The minimum hardware configuration could include an IBM PC/XT or compatible configured with a hard disk and monitor and printer. A larger municipality might use a network of IBM PC/AT's and/or a minicomputer based system. This range of hardware configurations and optional peripheral devices is the depicted in Exhibit 5.7.

The system hardware costs will vary considerably from municipality to municipality. It can be expected that the minimum hardware configuration, based on current prices, could be as low as $7,000. This would comprise an IBM PC/XT compatible and an associated monitor and printer. A larger configuration with additional main memory, additional disk storage and increased processing speed would typically cost approximately $11,000. In larger municipalities a computer network linking individual work stations would add approximately $600 per work station. A 3-6 user microcomputer based system for a large municipality would range in cost from $20,000 to $40,000.

EXHIBIT 5.7

SYSTEM HARDWARE CONFIGURATIONS

MINIMUM SYSTEM	OPTIONS
1 - IBM PC/XT/AT or Compatible	
- 512 KB Memory	640 KB
- 10 MB Hard Disk	20-30 MB
- 360 KB Floppy Disk	
- Monochrome Graphics Monitor	Colour
- Serial/Parallel Ports	
- 1 Dot Matrix Printer	Letter Quality
- MS-DOS, DBMS Software	

MAXIMUM SYSTEM

Option 1: 2^+ Workstations as above

- Local Area Network
- Tape Drive Storage

Option 2: 2^+ Terminal Multi-user Computer

- UNIX, DBMS Software
- 512 - 2000 kB Memory
- 40-80 MB Hard Disk
- Monochrome Terminals
- DOT Matrix Printers

OPTIONAL PERIPHERALS

- Plotter
- 9 Track Tape Drive
- Modems
- Data Collection Equipment
- Digitizer
- Colour Graphics Displays

5.5 ITS SYSTEM DEVELOPMENT COSTS

The mode of development of the Integrated Traffic System will have a great effect on its ultimate success and acceptance in the user community in Canadian municipalities. The ITS system must be developed as a joint enterprise between several levels of government and the private sector. The proposed development strategy, which was derived through a concensus of the Technical Advisory Committee, was the funding of the initial development through the funds of higher levels of government and the demonstration of the resultant system in two or more selected municipalities. These municipalities would bear their own staff costs in the demonstration phases, however, the initial hardware requirements could be funded through the demonstration project. It was recognized that efforts must be made during the demonstration project period to solicit the involvement of as many members of the user community as possible and to include adequate resources to broadcast the results of the demonstration to the user community in Canadian municipalities. For these reasons, it would appear that a demonstration in two or more municipalities would be the most beneficial development environment. The costs for system development and initial demonstration period support, including all hardware, is depicted in Exhibit 5.8 System Development Costs. It can be seen that substantial emphasis is placed on the detailed system design phase and the system documentation phase. It is these two tasks which will assure that the final product is usable and accepted by the Canadian traffic engineering community. The evaluation task would include the presentation of the results of the project to the traffic engineering community throughout Canada for their comments. The hardware costs outlined in Exhibit 5.8 anticipate the demonstration of the system in at least two municipalities.

5.6 MUNICIPAL IMPLEMENTATION SCENARIOS

The implementation of the Integrated Traffic System can best be described in four phases, namely: I - Market Study/Conceptual System Design, II - Development, III - Demonstration/Evaluation, IV - Implementation and support.

EXHIBIT 5.8

SYSTEM DEVELOPMENT COSTS

1.	Detailed System Design	$ 40,000
2.	System Development	60,000
3.	System Test/Implementation	30,000
4.	Evaluation	30,000
		$190,000
	Hardware (3 sites)	$ 60,000

The Market Study/Conceptual System Design has been the focus of this current project. The conclusions forthcoming from the Market Study would indicate not only a need for such a system but also that the various external market forces such as computer technology development, data collection device development and analysis package development would lead to a successful implementation at the current time. A conceptual systems design undertaken as part of this project identifies no areas of major difficulty in the implementation of an integrated traffic system. It would appear that at the current time the development and implementation of an Integrated Traffic System in municipalities in Canada is a viable undertaking.

The Development phase of the Integrated Traffic System would encompass the definition of the specific system functions to be included in the ITS system through input from the user community and the subsequent detailed design of the ITS system. This design phase would incorporate all existing knowledge as to the market needs, the existing hardware and software technology, the expected future developments in computer hardware and software, the available and expected automated data collection facilities and the needs of municipalities of various sizes.

The Demonstration/Evaluation phase would encompass the implementation of the Integrated Traffic System or portions thereof, in selected municipalities across Canada. This demonstration and evaluation phase would allow for both experimentation in the use of the Integrated Traffic System software and as a form for the promotion and acceptance of the ITS concept in other Canadian municipalities.

The Implementation/Support phase would include the on-going development and enhancement of the ITS package and its support in municipalities. It would be hoped that through the course of the demonstration phase a user community could be established and a formal Users Group be formed to carry on the refinement and growth of the ITS concept.

The implementation scenarios for the Integrated Traffic System will vary greatly depending on the size of the municipality involved. It can be expected that in a small municipality the major emphasis of the Integrated Traffic System will be the traffic operations and analysis functions, followed by the development of an infrastructure inventory. The accident data system with its inherent large data volumes and required linkages to external data sources might follow as a third priority. In larger municipalities, especially those who already utilize some form of accident data retrieval system, this portion of ITS might be implemented immediately. The other portions of the ITS package might be implemented on separate microcomputers, each dedicated to traffic operations and analysis and an infrastructure inventory. The data contained in all of these microcomputers can be readily exchanged between them as required for a particular analysis or investigation. It may also be expected that in larger municipalities direct linkages between the Integrated Traffic System and other information sources in the municipality would be required, for example, a linkage between a municipal maintenance management system which records road infrastructure repairs and the infrastructure inventory of the ITS system.

The municipalities chosen for the demonstration period should reflect the broad range of implementation scenarios possible within municipalities in Canada. Throughout any development and demonstration project, an on-going dialogue should be fostered and potentially formalized through a technical steering committee to ensure that the final Integrated Traffic System receives wide acceptance throughout the Canadian user community.

6.0 ESTIMATED BENEFITS

6.1 INTRODUCTION

This chapter discusses some of the benefits of an Integrated Traffic System (ITS). Having discussed the requirements of possible users of an Integrated Traffic System and the proposed system design in earlier chapters, there is a need to assess those areas that would benefit from the implementation of such a system and where possible, to quantify these benefits. These benefits can then be compared with costs to determine whether or not the development of such a system is justified. The analysis of benefits is fundamentally qualitative due in large part to the diversity of the organizational structure, existing facilities and responsibilities of system users and the applications of the Integrated Traffic System itself.

An Integrated Traffic System is expected to offer benefits to traffic agencies at the municipal and provincial levels of government and to some private sector firms. Although many of the benefits of an Integrated Traffic System were perceived prior to the initiation of this project they had not been documented. The operating environment and duties of each user will influence the magnitude and extent of the benefits described below.

The benefits attributable to the implementation of a micro-computer based Integrated Traffic System are considered to fall into the following categories:

- Travel benefits - Benefits such as reduced energy consumption and reduced vehicle delay.
- Increased safety - The potential to reduce accidents.

- o Information processing efficiency - There is a significant potential for improvement in the handling of data storage and processing (e.g. accident information).

6.2 TRAVEL BENEFITS

Although none of the benefits itemized above is easily quantifiable an attempt has been made to assess the magnitude of the impacts. One example of the benefit of an Integrated Traffic System is that it would allow traffic operations staff to review intersection signal phasing and implement improved signal timing plans. Studies have indicated that the improvement in vehicular progression and smooth traffic flow can be expected to offer energy reductions ranging from .26% area wide energy consumption in smaller cities (i.e. under 50,000) to 1.34% of area wide energy consumption in large cities (i.e. cities over 1 million population)[1].

In addition, reviewing the signal timing plans on a more frequent basis can be expected to offer some significant benefits. As the Integrated Traffic System allows the user to quickly determine optimal signal timing plans it follows that more frequent review of intersection signal time and phasing can be conducted in a similar time frame with existing staff. The impact of this feature alone has been estimated to reduce area wide energy consumption by .06%[2]. Exhibit 6.1 illustrates that these two areas alone could account for fuel savings in Canada of up to 210 million litres per year.

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1. A National Framework for Urban Transportation Energy Management, Prepared by IBI Group for the Transportation Development Centre and Energy Mines and Resources, Sept. 1983, TP 4793E.

2. Transportation Energy Conservation Plan, Prepared by IBI Group for the Regional Municipality of Ottawa-Carleton, 1984.

EXHIBIT 6.1

ESTIMATED ENERGY SAVINGS

POPULATION RANGE	10,000-50,000	50,000-100,000	100,000-350,000	350,000-1,000,000	1,000,000+	TOTAL
Number of Cities	108	15	15	6	3	
Annual Energy Consumption (millions of l.)	59	127	343	912	2,610	
Potential Annual Savings/City Size (millions of l.)						
1. More Frequent* Timings (.06%)	(0.06%) .035	(0.06%) .076	(0.06%) .206	(0.06%) .457	(0.06%) 1.566	16
2. Improved** Signal Timing	(0.26%) .152	(0.58%) .73	(0.65%) 2.2	(0.72%) 6.56	(1.34%) 34.9	194

* Transportation Energy Conservation Plan, Prepared by IBI Group for the Regional Municipality of Ottawa-Carleton, 1984.

** Transportation Energy Management Study, Prepared by IBI Group for the Regional Municipality of Hamilton-Wentworth, April 1982.

*** A National Framework for Urban Transportation Energy Management, Prepared by IBI Group for the Transportation Development Centre and Energy Mines and Resources, September 1983, TP 4793E.

Other benefits are also associated with reduced energy consumption including reduced fuel emissions and pollutants such as carbon monoxide and sulfur dioxide.

Although an Integrated Traffic System alone would not yield the above magnitude of benefits, it could make a valuable contribution. For example, if only 1% of all energy savings were attributable to the wide scale application of ITS, it would translate to some 2.1 million litres saved per year or over $1.0 million[3].

6.3 IMPROVED SAFETY

An improvement in traffic flow would help reduce the potential for rear end collisions on urban streets. For example, the City of Ottawa estimated a 20% reduction in total accidents and 40% reduction in rear end collisions[4] due to signal coordination with proper signal timings. If signal coordination could be improved due to ITS the accident benefits across Canada could be significant.

Also, it could be argued that the ability to more frequently review problematic intersections using an interactive data storage system offers the potential to reduce accidents further.

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3. Transportation Energy Management Study, Prepared by IBI Group for the Regional Municipality of Hamilton-Wentworth, April, 1982.

4. Transportation Energy Management Measures to Reduce Energy Consumption, Ontario TEMP, 1981.

6.4 INFORMATION PROCESSING EFFICIENCY

A significant benefit of an Integrated Traffic System is the ability for users to more efficiently store and retrieve information. Data from the survey described in Chapter 3 indicated that a major proportion of traffic department computer charges are related to the storage and processing of accident data. Most survey respondents indicated that significant annual computer charges are incurred (refer to Exhibit 3.3). The storage and processing of accident information represents a major proportion of present computer charges (e.g. 40-70%). The use of a microcomputer based Integrated Traffic System to handle accident data can be expected to significantly reduce or eliminate computer charges.

Other uses of the Integrated Traffic System would also have offsetting costs related to current computer charges for data storage and processing including use of rented or lease computer facilities for inventories, running standard analysis programs, etc. Using the survey results an estimate of the national annual computer charges is $950,000. If only a small proportion of this (eg. 10%) were assigned to the development of an ITS System, it would be justified.

A final indication of the benefits of a microcomputer based Integrated Traffic System are exhibited by the traffic departments "willingness to pay". Based on the survey response and input from the Steering Committee it was evident that there is a significant value placed on such a system. A discussion on the willingness to pay is presented in Chapter 3.

While the above discussion attempts to qualitatively address some of the more significant benefits of an Integrated Traffic System there are many subtle yet important benefits such as increased access to better information for management decisions, increased access to better traffic operations tools, the opportunity for standardizing many of the traffic operations functions throughout Canada or regions of Canada, etc. Also,

other activities associated with the implementation of an Integrated Traffic System such as interconnection of traffic signals and computerized signal control offer significant improvement in energy and delay reduction over and above those identified for improved signal timing.

Aside from this attempt to quantify and discuss the benefits, the consensus of the Steering Committee members was that such a system would be a valuable asset for Canada's Municipal and Provincial traffic organizations.

6.5 SUMMARY

The development of an Integrated Traffic System could be justified based on:

- reduced energy consumption;
- reduced motorist delay;
- increased safety;
- better and more efficient information processing;
- offsetting existing computer changes;
- municipalities willingness to pay for an ITS;
- traffic system improvements such as computerized intersection control associated with ITS.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the analysis of expected benefits and development costs, it is apparent that a microcomputer based Integrated Traffic System is justified. The justification is due to the benefits in a number of different areas including:

- o travel benefits, which result in reduced energy consumption, and delay;
- o improved safety through better analysis capabilities;
- o improved data processing efficiencies either as reflected in improved use of staff or reduced costs.

Based on the survey of needs, an Integrated Traffic System should include a number of basic functions including traffic engineering capabilities associated with:

- o traffic accident analysis, tabulating and reporting;
- o traffic operations analysis;
- o inventories;
- o use and integration of various generic programs including spread sheets, graphic packages etc.;
- o interface capabilities to external data collection devices including volume counters, intersection turning movement boards etc.

The Integrated Traffic System should be developed in an non-proprietory manner and structured in an open concept so that:

- o it can be easily adapted to the unique and varied needs of different jurisdictions and agencies;
- o it can evolve over time as new programs are developed and are incorporated into the basic system.

Because an Integrated Traffic System is considered to be justified, the next phase should proceed. The next phase would include:

- detailing the functional requirements of an Integrated Traffic System;
- undertaking the design of the database structure;
- evaluating various database management packages with respect to their suitability for both development and subsequent distribution to develop the ITS;
- assessing microcomputer hardware and its appropriateness, including the operating systems;
- the actual development of the Integrated Traffic System;
- a trial demonstration in selected cities;
- the preparation of a summary evaluation report.

APPENDIX A

SUMMARY OF HARDWARE AND SOFTWARE PRODUCTS/SUPPLIERS

LEGEND:
- ● PRIMARY FUNCTION
- ◐ SECONDARY FUNCTION
- ○ MINOR / RELATED FUNCTION

HARDWARE SUPPLIERS / PRODUCTS (1 OF 2)	MANUAL FIELD DATA COLLECTION	AUTOMATIC DATA COLLECTION	TRAFFIC SIGNAL TIMING OPTIMIZATION	HIGHWAY CAPACITY ANALYSIS	DOWNLOADING TRAFFIC SIGNAL TIMINGS	SPEED CHECK ANALYSIS	TRAFFIC VOLUME COUNT SUMMARIES	ACCIDENT DATA TABULATION	FACILITIES DESIGN	TRAFFIC SIMULATION	FACILITIES / EQUIP. INVENTORY	FACILITIES / EQUIP. MAIN.	STATISTICAL ANALYSIS	GRAPHICAL DISPLAYS	DATABASE MANAGEMENT	PROJECT MANAGEMENT	DATA FILE TRANSFER BETWEEN EQUIP.	TRAFFIC SIGNAL CONTROL	INTERSECTION CAPACITY ANALYSIS	OTHER ENG. APPLICATIONS
TIMELAPSE:																				
TMC/48	●																●			
TMC ANALYSIS SOFTWARE							●								○				○	
OMNIDATA:																				
DATAPOD		●															●			
G.K. INSTRUMENTS LTD:																				
TRAFFIC COUNTERS		●															●			
GOLDEN RIVER HIGHWAY & TRAFFIC DATA SYSTEMS:																				
TELMET		●					●								◐		◐			
MANGOOD LTD:																				
TELAC		●					●								◐		◐			

LEGEND:
● PRIMARY FUNCTION
◉ SECONDARY FUNCTION
○ MINOR/RELATED FUNCTION

HARDWARE SUPPLIERS/ PRODUCTS (2 OF 2)	MANUAL FIELD DATA COLLECTION	AUTOMATIC DATA COLLECTION	TRAFFIC SIGNAL TIMING OPTIMIZATION	HIGHWAY CAPACITY ANALYSIS	DOWNLOADING TRAFFIC SIGNAL TIMINGS	SPEED CHECK ANALYSIS	TRAFFIC VOLUME COUNT SUMMARIES	ACCIDENT DATA TABULATION	FACILITIES DESIGN	TRAFFIC SIMULATION	FACILITIES/ EQUIP. INVENTORY	FACILITIES/ EQUIP. MAINT.	STATISTICAL ANALYSIS	GRAPHICAL DISPLAYS	DATABASE MANAGEMENT	PROJECT MANAGEMENT	DATA FILE TRANSFER BETWEEN LOCATIONS	TRAFFIC SIGNAL CONTROL	INTERSECTION CAPACITY ANALYSIS	OTHER ENG. APPLICATIONS
MULTISONICS: VMS 220			○		◉													●		
ECONOLITE CONTROL PRODUCTS: KMC-10,000			◉		◉		○											●		
TRACONEX INC. HMP 290			○		◉		○											●		

LEGEND:
- ● PRIMARY FUNCTION
- ◐ SECONDARY FUNCTION
- ○ MINOR / RELATED FUNCTION

SOFTWARE SUPPLIERS / PRODUCTS (1 OF 4)	MANUAL FIELD DATA COLLECTION	AUTOMATIC DATA COLLECTION	TRAFFIC SIGNAL TIMING OPTIMIZATION	HIGHWAY CAPACITY ANALYSIS	DOWNLOADING TRAFFIC SIGNAL TIMINGS	SPEED CHECK ANALYSIS	TRAFFIC VOLUME COUNT SUMMARIES	ACCIDENT DATA TABULATION	FACILITIES DESIGN	TRAFFIC SIMULATION	FACILITIES / EQUIP. INVENTORY	FACILITIES / EQUIP. MAIN.	STATISTICAL ANALYSIS	GRAPHICAL DISPLAYS	DATABASE MANAGEMENT	PROJECT MANAGEMENT	DATA FILE TRANSFER BETWEEN COMP.	TRAFFIC SIGNAL CONTROL	INTERSECTION CAPACITY ANALYSIS	OTHER ENG. APPLICATIONS
ROGER CREIGHTON ASSOCIATES:																				
CAPCALC															○				●	
FHWA:																				
ITDS (INTEGRATED TRAFFIC DATA SYSTEM)			○				○	○		○	○				●		●			
MVA SYSTEMATICA:																				
MicroSURVEY							◐						◐		●					
TRAFFICQ			●							●										
TTY TERMINAL EMULATOR																	●			
DELCAN CONSULTING																				
TEE																			●	
LTC																			●	

LEGEND:
- ● PRIMARY FUNCTION
- ◉ SECONDARY FUNCTION
- ○ MINOR/RELATED FUNCTION

SOFTWARE SUPPLIERS/ PRODUCTS (2 OF 4)	MANUAL FIELD DATA COLLECTION	AUTOMATIC DATA COLLECTION	TRAFFIC SIGNAL TIMING OPTIMIZATION	HIGHWAY CAPACITY ANALYSIS	DOWNLOADING TRAFFIC SIGNAL TIMINGS	SPEED CHECK ANALYSIS	TRAFFIC VOLUME COUNT SUMMARIES	ACCIDENT DATA TABULATION	FACILITIES DESIGN	TRAFFIC SIMULATION	FACILITIES/ EQUIP. INVENTORY	FACILITIES/ EQUIP. MAIN.	STATISTICAL ANALYSIS	GRAPHICAL DISPLAYS	DATABASE MANAGEMENT	PROJECT MANAGEMENT	DATA FILE TRANSFER BETWEEN	TRAFFIC SIGNAL CONTROL	INTERSECTION CAPACITY ANALYSIS	OTHER ENG. APPLICATIONS
BARTON-ASCHMAN TEAPAC															●					
• TEAPAC SUPPORT SOFTWARE																			●	
• TRAFFIC OPERATIONS ANALYSIS & DESIGN			●	●					○	◉				○						
• SITE TRAFFIC ENG. SURVEY, ANALYSIS & DESIGN							●							○	●					●
• TRAFFIC AIR QUALITY MODELLING													●	○	●					
• SURVEY RESPONSE TABULATION																				
CITY OF EDMONTON/ U OF ALBERTA: RCOORD (ROUTE COORDINATION)			●											○						
SINTRAL (SIGNALIZED INTERSECTION ANALYSIS)			●											○						

LEGEND:
- ● Primary Function
- ◐ Secondary Function
- ○ Minor/Related Function

Software Suppliers/ Products (3 of 4)	Manual Field Data Collection	Automatic Data Collection	Traffic Signal Timing Optimization	Highway Capacity Analysis	Downloading Traffic Signal Timings	Speed Check Analysis	Traffic Volume Count Summaries	Accident Data Tabulation	Facilities Design	Traffic Simulation	Facilities/ Equip. Inventory	Facility/ Equip. Maint.	Statistical Analysis	Graphical Displays	Database Management	Project Management	Data File Transfer Routines	Traffic Signal Control	Intersection Capacity Analysis	Other Eng. Applications
Reg. Mun. of Niagara																				
IMSA (Intesection Movement Survey and Analysis)							●													
SSOA (Spot - Speed Observation and Analysis)						●														
ATVC (Automactic Traffic Volume Count)							●													O
SIGTIM (Signal Timing)			●																	
Grabowski Computing Services																				
Capacity																				●
ATR (Automated Traffic Recorder)								●												

LEGEND:
● PRIMARY FUNCTION
◐ SECONDARY FUNCTION
○ MINOR/RELATED FUNCTION

SOFTWARE SUPPLIERS/ PRODUCTS (4 OF 4)	MANUAL FIELD DATA COLLECTION	AUTOMATIC DATA COLLECTION	TRAFFIC SIGNAL TIMING OPTIMIZATION	HIGHWAY CAPACITY ANALYSIS	DOWNLOADING TRAFFIC SIGNAL TIMINGS	SPEED CHECK ANALYSIS	TRAFFIC VOLUME COUNT SUMMARIES	ACCIDENT DATA TABULATION	FACILITIES DESIGN	TRAFFIC SIMULATION	FACILITIES/ EQUIP. INVENTORY	FACILITIES/ EQUIP. MAINT.	STATISTICAL ANALYSIS	GRAPHICAL DISPLAYS	DATABASE MANAGEMENT	PROJECT MANAGEMENT	DATA FILE TRANSFER UTILITY	TRAFFIC SIGNAL CONTROL	INTERSECTION CAPACITY ANALYSIS	OTHER APPLICATIONS
URBAN NETWORK TRAFFIC SIMULATION MODELS:																				
• NETSIM			●	●					○	●				○	○					
• NETFLO																				
• CONTRAM																				
• TRANSIT																				
• SATURN																				
• MAXBAND																				
• PASSER II																				
• SIGOP II																				
• SSTOP																				
FREEWAY CORRIDOR TRAFFIC SIMULATION MODELS:																				
• INTRAS			○	●					○	●				○	○					
• DIVSUM																				
• FREFLO																				
• FREQ6PL																				
• CORQ																				
• CORCON																				

APPENDIX B

MICROCOMPUTER TRAFFIC ANALYSIS SURVEY QUESTIONNAIRE

SURVEY OF TRAFFIC/TRANSPORTATION ANALYSIS OPTIONS/NEEDS FOR MICROCOMPUTERS

INTRODUCTION

This survey which is being undertaken for Transport Canada, will be used to identify the need for, and requirements of an integrated traffic/transportation analysis capability.

Your assistance in completing this questionnaire would be appreciated. Should you have any questions please call: S. Stewart or D. Sims at IBI Group (416-596-1930).

NAME: _____

POSITION: _____

CITY: _____

ADDRESS: _____

_____

PHONE: _____

1. Please provide information on your current data collection storage and analysis activities by completing the table below:

TRAFFIC STUDY	FREQUENCY*	DATA * COLLECTION	DATA * STORAGE	DATA * ANALYSIS	ADDITIONAL COMMENTS
A. Volume Studies					
1. Spot Counts					
2. Area-wide					
3. Cordon Counts					
4. Screenline Counts					
5. Pedestrian Counts					
6. Intersection Counts					
7. Other					
B. Speed Studies					
1. Spot Speed					
2. Intersection Speed					
3. Speed Delay					
4. Other					

* The following list provides a guideline for survey response:

1. Frequency: Daily, weekly, monthly, semi-annually, annually, etc...
2. Data Collection: Manually, Mechanically, Microcomputer, Other
3. Data Storage: Summary Sheets, Microcomputer, Mainframe, Other
4. Data Analysis: List Method(s): eg. Hand Calculations, TRANSYT, SSTOP, TRAFLO, SATURN,...

TRAFFIC STUDY	FREQUENCY*	DATA * COLLECTION	DATA * STORAGE	DATA * ANALYSIS	ADDITIONAL COMMENTS
C. Intersection Studies					
1. Intersection Delay					
2. Intersection Capacity					
3. Gap Acceptance					
4. Queuing Studies					
5. Signal Warrants					
6. Intersection Design					
7. Other					
D. Traffic Network St.					
1. Signal Timing Optimization					
2. Other					

* The following list provides a guideline for survey response:

1. Frequency: Daily, weekly, monthly, semi-annually, annually, etc...
2. Data Collection: Manually, Mechanically, Microcomputer, Other
3. Data Storage: Summary Sheets, Microcomputer, Mainframe, Other
4. Data Analysis: List Method(s): eg. Hand Calculations, TRANSYT, SSTOP, TRAFLO, SATURN,...

TRAFFIC STUDY	FREQUENCY*	DATA * COLLECTION	DATA * STORAGE	DATA * ANALYSIS	ADDITIONAL COMMENTS
E. Other Studies 1. Parking Studies 2. Truck Loading 3. O-D Studies 4. Traffic Accidents 5. Licence Plate Surveys 6. Trip Generation/ Distribution 7. Other					

* The following list provides a guideline for survey response:

1. Frequency: Daily, weekly, monthly, semi-annually, annually, etc...
2. Data Collection: Manually, Mechanically, Microcomputer, Other
3. Data Storage: Summary Sheets, Microcomputer, Mainframe, Other
4. Data Analysis: List Method(s): eg. Hand Calculations, TRANSYT, SSTOP, TRAFLO, SATURN,...

2. Please identify whether the following inventories are maintained:

INVENTORY	YES/NO	IF YES, LIST METHOD OF DATA STORAGE	ADDITIONAL COMMENTS
1. Public Streets & Highways			
2. Intersection Plans			
3. Land Uses & Zoning Control			
4. Traffic Generators			
5. Traffic Control Devices			
- Traffic Signs			
- Traffic Signals/Controllers			
- Controller/Cabinet Components			
- Pavement Markings			
6. Transit System			
- Routes			
- Facilities			
7. Parking Facilities			
8. Street Lights			
9. Other			

3. Please complete the following section dealing with present computer resources used for traffic/transportation purposes.

3.1 Mainframe/Mini-Computer

1. Does the Department/City/Agency own a data processing computer: YES____ NO____

2. If charges are applied to the traffic department, what is a typical monthly or yearly charge: $_____

3. Does the department operate a traffic control computer: YES____ NO____

   If not, is the department contemplating the acquisition of a traffic control computer: YES____ NO____

   If YES, when _____

3.2 If micro-computers are used please complete the following:

MAKE/MODEL	# OF UNITS	OPERATING SYSTEM(S)	PROGRAMMING LANGUAGES	SOFTWARE PACKAGES
1)				
2)				
3)				
4)				

If microcomputers are not used, please state why:

_____

_____

4. What are the major traffic/transportation functions that you believe should be available on a micro-computer or which could be valuable if developed in an integrated package:

1. Check all that apply.
2. Place asterisks next to the three functions to which you devote the most time.

____	Manual Field Data collection	____	Facilities design
____	Automatic Data collection	____	Traffic simulation
____	Traffic signal timing optimization	____	Facilities/equipment inventory
____	Highway capacity analysis	____	Facilities/equipment maintenance
____	Intersection capacity analysis	____	Statistical analysis
____	Downloading traffic signal timings	____	Graphical displays
____	Speed check analysis	____	Data base management
____	Traffic volume count summaries	____	Project management
____	Accident data tabulation	____	Data file transfer between computers
____	Other engineering applications (Specify):	____	Traffic signal control
	_____		
	_____		

What could your organization justify as payment for an integrated traffic/transportation analysis system: (including both hardware and software packages).

- o For all items that have been checked: $_____.00
- o For those items identified with an asterisk: $_____.00

5. Do you or your associates:

Write programs Many_____ Some_____ None_____

Use application programs, if so please identify which ones: Spread Sheets_____

Data base packages_____

Word Processing_____

Graphics_____

Statistical Packages_____

Other_____

_____

* * * * * * * * * * *

COMMENTS:

_____

_____

_____

* * * * * * * * * * *

THANK YOU

APPENDIX C

PRELIMINARY REVIEW OF TYPICAL TRAFFIC ANALYSIS PROGRAMS

1. Accident

INPUT

- o New Report
- o Transfer Data

STANDARD REPORT

ANALYSIS

- o Historical
- o Geographical

OUTPUT

- o Reports
- o Tables
- o Summaries
- o Graph's

DATA ELEMENTS	
o Location	- Intersection - Street ID
o Report Number	
o Acc. Type	
o Time	
o Weather	
o Road Conditions	
o Visibility	
o etc.	

2. Traffic Volumes (Int. & Links)

INPUT

- New Data
- Transfer

STANDARD REPORT

ANALYSIS

- Historical
- Geographical

OUTPUT

- Reports
- Tables
- Summaries
- Graph's

DATA ELEMENTS	

INTERSECTIONS
o Intersection
o Date, Time, Duration
o Data Interval
o Approach
  o Volumes
  o Cars
  o Buses
  o Trucks
  o Pedestrian Volumes
o Type of Control
o Weather
o Surveyors
	LINKS
	o Location
	o Date, Time, Duration
	o Data Interval
	o Source

3. Intersection Cap. & Timing Analysis

DEFINE INPUT

- o Intersection
- o Volumes

ANALYSIS

- o Program - Soap
  - Cap. Calc.
- o Change Variables

OUTPUT

- o Tables
- o Graphics
- o Charts

DATA ELEMENTS

INPUTS
INTERSECTION

- o Name
- o Approaches
  - o # of Lanes
  - o LT/RT Ex. Lanes
  - o Bus Stops
- o Signal
  - o Phasing
  - o Cycle Length
  - o Int. Timings
  - o Ped. Walk Times
- o Volume
  - o Date, Time, Dur., Int.
  - o Approach
    - o Cars
    - o Buses
    - o Truck
    - o Pedestrians

OUTPUTS
INTERSECTION

- o Name
  - o Signals
    - o Phasing
    - o Cycle Length
    - o Timings
  - o Measures of Effectiveness
    - o Capacity
    - o V/C
    - o Delay
    - o Energy Consumption

4. Arterial & Network Optimization

DEFINE INPUT

- o Intersection
- o Links
- o Volumes

ANALYSIS

- o Program - Maxband
  - SSTOP
  - Transyt 7F
- o Change Variables

OUTPUT

- o Tables
- o Graphics
- o Charts

DATA ELEMENTS	

INPUTS
INTERSECTION NODES
 	
o Approaches
  o # of Lanes, etc.
  o Bus Stops
o Signal
  o Phasing
  o Timings
o Links
  o Length
  o Speeds
  o Generators
o System Parameters
  o Platoon Dispersion Factor
o Volumes
  o Date, Time
	OUTPUTS
	INTERSECTION NODES
	
	o Signal
	  o Phasing
	  o Timings
	o Links
	  o Speeds

5. Signal Equipment Inventory

DEFINE INPUT

- Signal Plant
- Signal Operations

ANALYSIS

- Summaries
- Maintenance Reports
- Exception Reports

OUTPUT

- Reports
- Work Orders
- Tables
- Graphics

DATA ELEMENTS	
INPUTS	**OUTPUTS**
o Location Equipment	Summaries
o Controllers	Reports
o Detectors	
o Cabinets	
o Signal Heads	
o Wiring	
o Maintenance Records	
o Signal Operation	
o # of Phases	
o Signal Timing	
o Costs	

6. Signal Warrants

INPUT

- Intersection
- Volumes
- Warrants

ANALYSIS

- Justification

OUTPUT

- Tables

DATA ELEMENTS

INTERSECTIONS

- Accident Data
- Approaches
  - # of Lanes, etc.
- Volume
  - Cars
  - Buses
  - Trucks
  - Pedestrian

7. Site Impact Analysis

INPUT

- o Dev. Characteristics
- o Traffic Characteristics

ANALYSIS

- o Capacity Calculations
  - o Cap Calc.

OUTPUT

- o Tables
- o Charts
- o Graphics

DATA ELEMENTS	
INPUTS	OUTPUTS
o Site Characteristics o Size o Location o Access o Uses o Travel Assump. o Intersections o Approaches o # of Lanes, etc. o Volumes	o Generated Traffic o Capacity Cal. o MOE's

8. Special Studies

INPUT

- o Type Determined by Study
- o Direct Input or Data Trafer

ANALYSIS

- o Speed - Headway
- o Delay - Sat. Flow

OUTPUT

- o Charts
- o Tables
- o Graphics

DATA ELEMENTS
o Defined by Type of Study

9. Lighting Inventory

INPUT

- New Data
- Transfer
- Maint. Reports

ANALYSIS

- Summaries
- Exception Reports
- Maint. Reports

OUTPUT

- Tables
- Graphs

DATA ELEMENTS	
INPUTS	**OUTPUTS**

o Location
o Equipment
  o Pole
  o Ballast
  o Power
  o Wiring
o Maintenance
o Costs
	o Summaries
	o Reports

10. Simulation Models

INPUT

- Internal/External Data
- Locations

ANALYSIS

- Models - NETSIM
  - TRAFFIC

OUTPUT

- Model Outputs

DATA ELEMENTS
o Determine by Model

11. Road System Inventory

INPUT

- o Road/Street Data
- o Maintenance Reports

ANALYSIS

- o Summaries
- o Maintenance Reports
- o Except Reports

OUTPUT

- o Reports
- o Tables
- o Summaries

DATA ELEMENTS

- o Location
  - o Width
  - o # of Lanes
  - o St. Sewers/Sa. Sewers
  - o C.G.
  - o Sidewalks
  - o Right-of-Way
  - o Type of Surface
  - o Condition
  - o AADT
  - o Speed

12. Planning Models

INPUT

- Road Network Data
- Land Use Data

ANALYSIS

- System 33

OUTPUT

- Model Outputs

DATA ELEMENTS
o Determined by Model